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And set to View

In FOUR PARTS.

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By BATTY LANGLET.

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Tracts Geometrically

Applied to the Liberal Arts of

Building, Surveying, Gardening, and Agriculture

Calculated for the Service of

Country Gentlemen as well as Artificers

And fit to View

IN FOUR PARTS

THE FIRST PART

Containing the Principles of Geometry, and the Properties of the Circle, the Square, the Triangle, and the Polygon, with the Method of Finding the Area of any Figure, and the Perimeter of any Polygon.

THE SECOND PART
Containing the Principles of Trigonometry, and the Properties of the Circle, the Square, the Triangle, and the Polygon, with the Method of Finding the Area of any Figure, and the Perimeter of any Polygon.

THE THIRD PART
Containing the Principles of Statics, and the Properties of the Circle, the Square, the Triangle, and the Polygon, with the Method of Finding the Area of any Figure, and the Perimeter of any Polygon.

THE FOURTH PART
Containing the Principles of Dynamics, and the Properties of the Circle, the Square, the Triangle, and the Polygon, with the Method of Finding the Area of any Figure, and the Perimeter of any Polygon.

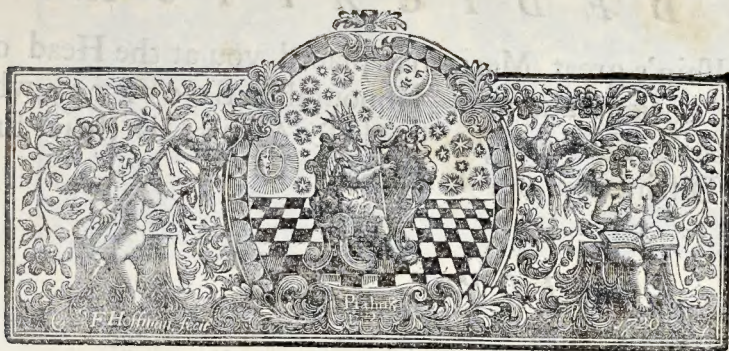
THE FIFTH PART

Containing the Principles of Pneumatics, and the Properties of the Circle, the Square, the Triangle, and the Polygon, with the Method of Finding the Area of any Figure, and the Perimeter of any Polygon.

THE SIXTH PART

Containing the Principles of Acoustics, and the Properties of the Circle, the Square, the Triangle, and the Polygon, with the Method of Finding the Area of any Figure, and the Perimeter of any Polygon.

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TO THE

Lord PAISLEY.

My LORD,



ALL who are acquainted with the Subjects of the following Treatise will acknowledge my Judgment in the Choice I have made of your Lordship's Name, which can not fail to recommend it to the perusal of the Public; And though an Author is very unwilling to beleive his Works destitute of real Merit and Usefulness, yet if this Book shall meet with Approbation, I am sensible how much will be owing to your Lordship's Patronage, whose known Skill in these Sciences is the Foundation of this Trouble.

Permit me to add, that I have a particular Pleasure in doing myself this Honour at a Time when your
A 2 Lordship's

D E D I C A T I O N.

Lordship's great Merit has placed you at the Head of a most Ancient and most Honourable SOCIETY, whose profound Knowledge, in these Affairs, is their Pride and Distinction. I am,

My LORD,

Your Lordship's most Obedient,

Most Humble,

And most Devoted Servant,

B. Langley.





P R E F A C E.



THE subjects of the present treatise, on account of their antiquity, usefulness and entertaining variety, having been the delight of the greatest masters in knowledge, thro' various ages, are, it must be acknowledged, transmitted to us in a suitable degree of perfection. They have indeed been largely treated of by various hands, but generally in a theoretical, rather than in a practical manner, so as to appear somewhat intricate and obscure to such as were not acquainted with the principles of mathematics, or have not applied themselves in earnest thereto. My design therefore is to treat of architecture, gardening, mensuration and Land-surveying, in a method as easy and intelligible as it is new and generally useful. I shall begin with the fundamental, or first principles of these several arts, and gradually conduct my reader from the easier parts of 'em up to the hardest, taking particular care all along to let him see the *utile* as well as the *dulce* thereof; the fruitful practice, and not the barren theory only. From a failure of authors in this point, I apprehend it is that these arts are at present much less cultivated than they merit. An author cannot do them greater justice, than to paint them as they are, most useful and delightful employments; of great importance in human life. To convince the world of this truth, as it is the design, so it wou'd be the highest recommendation of the present treatise. And this I can sincerely say, that I have had a view thereto thro' the execution of the whole design. I shall not therefore offer at any recommendation of the arts themselves, which want no able hand to set them off with colours, and the winning charms of rhetoric; but leave my reader, from the plain, naked, artless facts and observations he will meet with in the work, to determine of their merit. And I am greatly mistaken if to all true judges this does not appear a more equitable, and more unexceptionable procedure than to write, as the usual manner is, an encomium of the arts I treat of, in order to recommend the work. For if the book cannot be supported by its own merit, I am sure a panegyrick upon its subject will but render it the more ridiculous and contemptible. All that I request is a fair and candid perusal. I desire only that my reader wou'd come with a mind prepared not to be startled, or prejudiced against the author, by the appearance of novelty back'd with reason; tho' it at first sight shou'd seem to thwart some current and prevailing opinions. This were a temper that wou'd for ever exclude the light, and dronishly re-

main content with whatever doctrine happens to have its run. But we of late have seen such successful inroads made into opinions once thought just, that we cannot be too suspicious of our entertaining establish'd errors for truth, and shutting our eyes against plain fact and obvious reason. 'Tis not that I pretend to a faculty beyond that of others in discovering the truth in the particular subjects I have here treated; but my genius leading me to such kind of studies, I hope I may be allowed to have observed the common things, and to make my own use of them. If what I alledge be true, (for which I always give my reasons) the world will have the advantage; but if it shall prove to be false, I shall willingly bear the blame: Only I make this request, that I may be censured by the proper judges, and such as have been conversant in the same kind of studies with my self; otherwise the world, I hope, will agree with me, that I am condemn'd unjustly. That the reader may form the better judgment of the performance, he may be pleas'd to take the following account thereof.

Geometry being the basis of architecture, gardening, mensuration and land surveying, (which are the subjects of this treatise) I have in the first part, laid down all the most useful and necessary geometrical definitions, problems, theorems, and axioms, that are absolutely necessary to be well understood by every one who desires to be a complete artisan, and those in a most concise and familiar manner. The second part contains the application of the first to practise in the geometrical construction of all kind of scales for the delineating, and mensuration of all sorts of plans and uprights, and of the *Tuscan*, *Dorick*, *Ionick*, *Corinthian*, *Composite*, *French* and *Spanish* Orders of architecture, with their derivation, proportion, &c. in general. And seeing that neither ancient or modern architects have yet agreed on the measures of the principal parts of entire columns: I shall therefore before I proceed any further, demonstrate the same particularly.

The principal parts of entire columns are three, *viz.* The pedestal, the column, and the entablature; all which are severally divided into three other parts. As first, the pedestal by its base, die, and cornice; the column by its base, shaft and capital, and the entablature by its architrave. Freeze and cornish, whose several heights and projections are measured by modules and minutes. (*Vide prob. the 9th sect. 1. part 2d.*)

(1.) Pedestals, (called by the ancients *Stylobate*) are of two kinds, *viz.* The one broken, and the other continued. Broken pedestals, are parts of a continued pedestal, which project or break out, right under each column, as in the Theatre of *Marcellus*, the arches of *Titus*, *Septimius*, and *Constantine* in the *Coliseum*, and in the altars of the *Pantheon*. Continued pedestals are such as range throughout, without projections or breaks under each column, as in the Goldsmith's arch, the temple of *Vesta* at *Tivoli*, and that of *Fortuna Virilis*.

Both ancient and modern architects have delivered rules for the heights of entire pedestals, but all different, whereby the young architect is at a loss to know, among the several, which is the best.

Palladio makes the height of the *Tuscan* pedestal three modules; the *Dorick* four modules and five minutes; the *Ionick* five modules four minutes; the *Corinthian* five modules one minute, and the *Composite* six modules seven minutes.

Scamozzi makes the height of the *Tuscan* pedestal three modules twelve minutes; the *Dorick* four modules eight minutes; the *Ionick* five modules; the *Corinthian* six modules eleven minutes, and the *Composite* six modules two minutes.

Vignola

Vignola makes the height of the *Tuscan* pedestal five modules; the *Dorick* five modules four minutes; the *Ionick* six modules, and the *Corinthian* and *Composite* seven modules each.

Serlio makes the height of the *Tuscan* pedestal four modules fifteen minutes; the *Dorick* six modules; the *Ionick* six modules; the *Corinthian* six modules fifteen minutes, and the *Composite* seven modules four minutes. The height of the *Ionick* pedestals at the temple of *Fortuna Virilis*, is seven modules twelve minutes; those of the theatre of *Marcellus* three modules eight minutes, and at the *Coliseum* four modules twenty two minutes.

The height of the *Corinthian* pedestals, at the altars of the *Pantheon*, are seven modules twenty eight minutes; the *Coliseum* four modules two minutes, and the *Composite* pedestals of the Goldsmiths-arch, seven modules eight minutes.

Now since 'tis absolutely necessary, that these diversities should be reduced to a mean proportion, for a standard measure, therefore I have done it, and is as following, *viz.* Make the entire height of the *Tuscan* pedestal equal to two diameters or modules. The *Dorick* to two modules twenty minutes; the *Ionick* to two modules forty minutes; the *Corinthian* to three modules, and the *Composite* to three modules twenty minutes, the progression being of forty minutes.

N. B. That a module is a length equal to the diameter of the base of the column, divided into sixty equal parts called minutes.

The difference in the proportions of the parts of pedestals, are as great as those of their heights, and therefore I have also established this one general proportion for the parts of all pedestals, *viz.* Divide the height of any pedestal (be it *Tuscan*, *Dorick*, *Ionick*, *Corinthian* or *Composite*) into one hundred and twenty equal parts, and of those parts give to the socle twenty, to the mouldings of the base ten; to the die or trunk seventy five, and to the cornice fifteen.

The proportions assigned for the projecture of the base and cornice of pedestals, by both ancient and modern architects, are as various as their other parts, and therefore in this point also, I have reduced the diversities to a mean proportion, that thereby a general rule may be observed throughout the five orders, *viz.* In any order, be it *Tuscan*, *Dorick*, *Ionick*, *Corinthian*, or *Composite*, make the bases of pedestals, (exclusive of their zocolo or plinth) with a projecture equal to their altitude, which being different in every order, will therefore cause the projecture of the base to be different in each order. In the projecture of cornices of pedestals, made by either ancients or moderns, there is but little difference, for they usually make their projecture equal to (or very little more, than) that of the base, of which the last is to be preferr'd; and therefore, for a standard rule, I give the following proportions, for the projecture of both base and cornice, as follows, *viz.* To the *Dorick* pedestal, I give to the projecture of the base twelve minutes, and to the cornice fourteen. To the *Ionick* pedestal I give to the projecture of the base fourteen minutes, and to the cornice seventeen. To the *Corinthian* pedestal, I give to the projecture of the base fifteen minutes, and to the cornice nineteen. And lastly, to the *Composite* pedestal, I give to the projecture of the base sixteen minutes, and to the cornice twenty two.

I shall now mention another particular belonging to pedestals, as is common in all the orders, (and then proceed to the proportions belonging to columns) which is as follows: That the breadth of the die of every pedestal be always equal to the projecture of the base of its column.

The

The projecture of the bases of columns, is also an unsettled part of architecture. For to the *Tuscan* base *Palladio* and *Scammozzi* allow each forty minutes, as also hath the *Trajan's* column, but *Vignola* allows forty one, and *Serlio* forty two minutes. To the projecture of the *Dorick* base, *Palladio* allows forty minutes, *Scammozzi* forty two, *Vignola* forty one, *Serlio* forty four, and at the *Coliseum* forty minutes.

To the projecture of the *Ionick* base, *Palladio*, *Scammozzi*, and *Serlio* allow forty one minutes; *Vignola* forty two; the temple of *Manly Fortune* forty three; and the *Coliseum* forty minutes. To the projecture of the *Corinthian* base, *Scammozzi*, *Serlio*, and the *Coliseum* allow forty minutes; the portico of the *Pantheon* forty one; the three columns of *Campo Vaccino*, the baths of *Dioclesian*, *Palladio*, and *Vignola* allow each forty two, and the pilasters of the portico of the *Pantheon* forty three.

And lastly, to the projecture of the *Composite* base, the temple of *Bacchus*, the arch of *Septimius*, *Scammozzi*, and *Serlio*, allow each forty one minutes, *Palladio* and *Vignola* forty two; the baths of *Dioclesian* forty three, and the arch of *Titus* forty four minutes. Hence it appears, that forty two minutes is a mean proportion, between the extremes, and is what I recommend for the projecture of the bases of columns in general.

The great diversity of the lengths of columns of the same order assign'd by architects, is a very difficult point to account for: To the length of the *Tuscan* column *Vitruvius* *Palladio*, and *Vignola*, give seven diameters or modules. *Scammozzi* seven and an half. The *Trajan's* column eight, and *Serlio* but six diameters.

To the length of the *Dorick* column, *Vitruvius* in temples, allowed seven diameters; but in *Portico's* of temples seven diameters and an half; at the *Coliseum* they consist of nine diameters and an half; and at the theatre of *Marcellus* seven modules and fifty minutes; *Scammozzi* gives eight and an half; and *Vignola* eight diameters only.

To the length of the *Ionick* column, *Vitruvius*, *Palladio*, and *Serlio*, give eight diameters forty minutes, as also is the *Coliseum*, and theatre of *Marcellus* at *Rome*.

To the length of the *Corinthian* column, *Vitruvius* gives nine diameters thirty minutes, and *Serlio* nine diameters only; at the porch of the *Pantheon* they are nine diameters thirty six minutes.

The temple of *Pantheon* they are nine diameters, thirty six minutes. The temple of *Vesta* nine modules thirty nine minutes. The temple of the *Sibil* eight modules sixteen minutes. The *Coliseum* eight modules thirty seven minutes.

The temple of *Peace* nine modules thirty two minutes: The arch of *Constantine* eight modules thirty seven minutes: The three columns of the *Campo Vaccino*, ten modules six minutes; the porch of *Septimius* nine modules thirty eight minutes; the temple of *Faustina* nine modules thirty minutes, and the *Basilic* of *Antoninus* ten modules exactly.

To the length of the *Composite* columns, *Scammozzi* gives nine modules forty minutes, and the same is at the temple of *Bacchus*; the arch of *Septimius* nine modules thirty minutes, and the arch of *Titus* ten modules precisely.

Now

Now, because 'tis reasonable, that a proportionable length should be established for the length of columns in general, I have therefore reduced the extremes of their diversities to a mean proportion as following, *viz.* Make the height of the *Tuscan* column equal to seven diameters or modules, and twenty minutes; the *Dorick* to eight modules; the *Ionick* to eight modules forty minutes; the *Corinthian* to nine modules twenty minutes, and the *Composite* equal to ten modules only. So will their progression be proportionable, consisting of forty minutes in each column.

The diminishing of columns being first assign'd for that beautiful appearance, as flows therefrom, is made in three different manners. As first, to begin the diminution at the base of the column, and continue it to the capital. The second is to make the column thicker towards the middle, than at its base, diminishing of it towards the base and capital, which kind of diminution is called the swelling. The third and last way is according to the antique manner: Beginning the diminution at one third of the height above the base of the column, as is shewn in folio 63 hereof, and is the most beautiful kind of diminution.

The difference and quantity of diminution in each of the orders, is exhibited in sect. 2. Part 2. hereof.

There being yet no certain determin'd proportion for the height of the astragal and cincture, which terminate the shaft of a column. I therefore have also reduced those members, to such a proportion, as may be applied throughout the orders in general. As first to the cincture, I give three minutes, and to the astragal three minutes and one third. In the *Pantheon*, the temples of *Vesta* and *Manly Fortune*, and arch of *Titus*, the cinctures are very near three minutes. And in the temple of *Antoninus* and *Faustina* something more, as also the temple of *Bacchus*, the arch of *Septimius*, and in the bath of *Dioclesian*, from which I have extracted my mean proportions.

The received proportion for the height of the bases of each order is, to make them equal to the semidiameter of the column at its base, the *Tuscan* excepted, in which the cincture is included, which in other orders is not.

In the five orders of architecture, there are three different heights of Capitals. The *Tuscan* and *Dorick* capitals are always equal to the height of their base. The *Ionick* capital, from the top of the abacus to the point of interfection, where the cathetus and voluta intersect each other, at the bottom of the volute; to the semidiameter and an eighteenth part thereof. And lastly, the *Corinthian* and *Composite* capitals to one module and ten minutes.

But, notwithstanding that these measures are assigned for the height of capitals, yet 'tis to be observed, that the ancients did not observe them strictly. For the capital of *Trajan's* column (which is of the *Tuscan* order) is less than the semidiameter of the column's base, by a full third; and in the *Dorick* capital of the theatre of *Marcellus*, its height is almost thirty three minutes, and that of the *Coliseum* near thirty eight minutes: Nay, in the *Corinthian* capital of *Vitruvius* (the father of architects) he makes its height but fifty minutes: And therefore I finding that its height was not sufficient, have introduced a modern capital in its stead. At the temple of the *Sibyl* at *Tivoli*, the height of the *Corinthian* capitals are but forty seven minutes. In the frontispiece of *Nero* sixty six minutes, and in the temple of *Vesta* at *Rome* almost sixty eight minutes. And lastly, the height of the *Composite* capitals of the arches of *Septimius* and the Goldsmiths, are but fifty eight minutes and an half, and the temple of

Bacchus sixty fix. Hence appears the opposite diversities, from which are established the mean proportions before delivered.

And altho' the proportions of the aforesaid capitals are very different from each other, yet there is a far greater difference in the height and projecture of entablatures, which they with their columns support.

To the height of the *Tuscan* entablature, *Vitruvius* allows one hundred and five minutes, *Palladio* one hundred and four minutes, *Scamozzi* one hundred and twelve, *Vignola* one hundred and five, and *Serlio* ninety minutes.

To the height of the *Dorick* entablature, *Vitruvius* allows one hundred and twenty minutes (equal to two modules) *Palladio* one hundred and thirteen minutes; *Scamozzi* one hundred and twenty seven minutes; *Vignola* one hundred and twenty; *Serlio* one hundred and twelve; and the like of all other Masters, as are set forth in the 19, 21, 22, 24, 25, 26, 27, 28, and 29th plates hereof, to which I refer.

Now seeing that the beauty of an order doth consist in a proportionable entablature; therefore to prevent the destruction thereof, by having entablatures either of such a size: that they seem utterly insupportable, as those of *Campo Vaccino*, and the frontispiece of *Nero*, or on the contrary, too mean and pitiful as the entablatures of *Bullant* and *Delorme*; I advise that the height of all entablatures be always equal to two diameters, or one hundred and twenty minutes, and their projecture of the cornice, equal to the height thereof in the *Tuscan*, *Ionick*, *Corinthian* and *Composite* entablatures, and the *Dorick* entablature also, where the cornice is made without mutules, (as in that famous structure the *Coliseum*). But when the *Dorick* entablature hath mutules introduced, their length requires the entire cornice to have more projecture than height.

Having thus demonstrated the proportions of the principal parts of columns, I shall now proceed to the remaining part of my preface.

The third section of part 2. contains many excellent architectonical axioms and analogies, collected from most grand masters.

The fourth section of part 2. contains the use of an inspectional plain scale, which furnishes the young student not only with all kind of scales, but readily divides the several parts of a building instantly.

The fifth section of part 2. contains trigonometrical definitions, with the construction of chords, sines, tangents, half tangents, secants and versed sines, applied to practice in the solution of the twelve cases of plain trigonometry, which is performed geometrically also, by the help of a plain scale and pair of compasses, in a very concise and familiar manner.

The sixth section of part 2. contains the geometrical construction of draughts, plans, maps of gardens, farms, &c. Wherein is shewn how to perform such works, much more expeditious and exact than any author yet extant.

The third part contains all the most useful geometrical axioms and analogies for the mensuration of any superficial figure or solid body.

The fourth section of part 3. contains the measures, and manner of taking the dimensions of all kinds of work relating to building, as Carpenters, Glaziers, Joiners, Painters, Plasterers, Masons, Bricklayers, Paviers, &c.

The

The fourth part contains divers inspection tables of mensuration, whereby any dimension may instantly be cast up, without the assistance of multiplication, or even such capacities as are not masters of cros multiplication, are hereby enabled to measure any work with as great accuracy, as the best accomptant.

The first, second, third, fourth, fifth, sixth, seventh, eighth, ninth, tenth, eleventh, twelfth, fifteenth, sixteenth and seventeenth plates, being those which the several subjects hereof have recourse to, need not in this place say any thing thereof.

The thirteenth and fourteenth plates contain a new system of gardening, wherein 'tis shewn what great improvements may be made, even in the finallest of gardens; for by the method there observed, a small garden may be made to appear as a very large one; and such as are very large, to become the most noble and delightful.

And because no gardener can well understand the true manner of laying out a garden, even in any manner as bears any proportion, without well understanding the elements of geometry; therefore for his sake, in the first part hereof, I have laid down all as is necessary to be known in a most concise and easy manner, and applied to practice in the geometrical construction of all kind of lines and figures, as are requisite for his purpose in the practice of gardening. Perhaps that some may expect that I should herein treat of the culture of lands, the management of fruit trees, &c. which are parts as doth not relate to the mathematical part of gardening, as in designing, drawing, laying out, &c. But if God permits, I shall speedily communicate a treatise thereof, wherein I shall discover many curious experiments, as will prove both pleasant and advantageous to all lovers of gardening.

The eighteenth, nineteenth, twentieth, twenty first, twenty second, twenty third, twenty fourth, twenty fifth, twenty sixth, twenty seventh, twenty eighth and twenty ninth plates, contain the geometrical profiles and elevations of the five orders of architecture, as laid down by all the grand masters, both ancient, antique, and modern.

The thirty and thirty first plates are designs for the entrance into shady walks; the first into a right lined walk, and the other into a curved, or artificial walk, and those are delineated according to the truth of perspective.

The thirty third plate contains two designs for the enterances into *Grottos* according to the grand manner.

The thirty fourth plate contains divers capitals of the *Corinthian* and *Composite* orders, taken from the works of *Vitruvius*, and *Andrew Bosse*, with an elegant elevation of a noble structure after *Palladio*.

The thirty fifth, thirty sixth, thirty seventh, and thirty eighth plates contain divers geometrical elevations of doors, neathes, &c. of the *Tuscan*, *Doric*, *Ionick*, *Corinthian* and *Composite* orders, adorned with His most Sacred Majesty King *GEORGE*; their Royal Highnesses the Prince and Princess, whom God preserve.

The thirty ninth plate contains divers excellent designs for chimney-pieces, collected from the best of masters.

And

And the fortieth plate, the geometrical elevation of the portico of St. Mary the *Egyptian*, with a *Corinthian* frontispiece from the Ancients, and the imposts of the *Tuscan*, *Dorick*, *Ionick*, *Corinthian* and *Composite* orders.

Having thus, by way of preface, explain'd the several parts of the work, I now recommend you to the practice, desiring that you wou'd read and examine it, without critical envy, free from pre-occupation that may obscure your Judgment, and hinder your acknowledging the truth of what I have here presented for your improvement.

Therefore be not adviſed by ſuch as condemn a conception when they underſtand it not; and believe it falſe becauſe 'tis new; neither imitate thoſe, who ſeeking only to carp at words, neglect the ſenſe of the ſubject.

B. Langley.



T H E



A

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O F T H E

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T H E
P R A C T I C E
O F

*Architècture, Gardening, Mensuration, and
Land-Surveying, Geometrically demonstrated.*

P A R T I.

Of such Geometrical Elements as are absolutely necessary to be well understood by every Person who desires to well understand the TRUTH of LINEAL ARCHITECTURE, GARDENING, and MENSURATION universally.

S E C T. I.

Of Geometrical Definitions and Rudiments.

P L A T E I.

(I.)



Point in the practice of geometry, is the least superficial appearance as can be made by the point of a pen, pencil, pin, &c. as the point A, and is to be divided by the mind, tho' not by the hand, into any number of parts, as is conceived, Fig. I. notwithstanding that *Euclid*, and many

other famous geometricians, has defin'd a point to be neither quantity or part of quantity, and therefore not to

B

be

Of Geometrical Definitions

be divided into parts: but how 'tis demonstrated, neither he or any other has set forth.

(2.) A line in the practice of Geometry, is a length, with such a breadth, as is given thereunto by the point of the pen, pencil, &c. as describes the same, which is quite contrary to all other authors, who define a line to be a length without breadth or thickness, but without any sort of demonstration whatsoever to prove the same.

(3.) Of lines there be divers kinds, as right, circular, elliptical, parabolical, hyperbolical, &c.

Fig. II.

(4.) A right line is generated by the point of a pen, pencil, &c. moving from one point to another, the nearest way; therefore a right line is the nearest distance contain'd between two points, as the distance between the points A, B. The end or limits of all right lines are points, as the points A B.

Fig. III.

(5.) A circular line is generated by the motion of one end of a right line. Suppose A C to be a right line, fix'd at C as on a center; then by moving it out of the position A C to C B, the point A will describe or generate the arch, or circular line, A B; and if you move it forward to its former position A C, the point A will describe or generate the circumference of a circle.

Fig. IV.

(6.) An elliptical line, or ellipsis, is generated by an oblique section of a cylinder.

Fig. V.

(7.) A parabolical line is generated by a parallel section of a cone. As also a hyperbolical curve, the former to the side, and the latter to the axis.

(8.) As points terminate lines, so do lines superficial figures.

Fig. VII.

(9.) A superficial figure hath length and breadth only, and is contain'd under one termination or many. So A is contain'd under one line or termination, B under two, C under three, D under four, E under five, &c.

(10.) A circle is a plain geometrical figure, contain'd under one line, called the periphery or circumference.

Fig. VII.

(11.) Every circumference of a circle is described according to the 5th hereof, and the point on which the describer rests, is the center. So in Fig. III. the point C is the center thereof. Therefore, as the center of a circle is the exact midst of the same, all right lines drawn from thence to the circumference, are equal one to the other, as in Fig. VII. A B is equal to B C, and that to B D, &c.

Fig. VIII.

(12.) The diameter of a circle is a right line drawn through the center, and ending at the circumference, as the line A B C.

(13.) The radius, or femidiameter of a circle, is half the diameter.

(14.) A section, segment, portion, or part of a circle, is a figure contain'd under one right line, and part of the circumference. So the right line A B divideth the circle into two unequal parts, and are the sections, segments, portions, or part of that circle. Fig. IX.

(15.) A femicircle is one half of a whole circle, as the figure A.

(16.) A quadrant is one half of a femicircle, as the figure B. Fig. X.

(17.) The radius of a quadrant, is either of the streight sides, as nm , or mo , and the circular side no is called the limb, which is always divided into degrees and min. as will hereafter be fully shewn in its proper place.

(18.) An ellipsis is also a plain geometrical figure, contain'd under one line, called the circumference, and is generated according to the 6th hereof; and as the diameters of a circle are equal to each other, so likewise are the diameters of one ellipsis to another, when both are of the same dimension, but at no other time. Therefore in ellipsis's there is a great variety contain'd.

(19.) Every ellipsis hath two diameters, the one longer than the other; the longest diameter is called the conjugate diameter, and the shortest the transverse diameter; the point of intersection of both diameters as A, is the center of the ellipsis. Fig. XI.

(20.) A triangle is a geometrical figure contain'd under three sides, and is either right lined as the triangle A, or circular as C, or mix'd as B. Fig. XII.

(21.) When a geometrical figure consists of four sides and angles, and all equal as the figure B, such a figure is called a quadrat, or geometrical square; but if of the four sides, two be longer than the other, each to its correspondent, and the angles equal as the figure C, 'tis called an oblong, long-square, or parallelogram; also when the sides be all equal, and the angles unequal, as the figure D, such a figure is called a rhombus or diamond form; but if such a figure should have two sides longer and two shorter, each to his opposite corresponding, as the figure E, 'tis called a rhomboyades; and when the sides are all unequal, and the angles the same as the figure F, such a figure is called a trapezium. Fig. XIII.

(22.) When any figure contains more than four unequal sides, and angles, such are in general called irregular figures.

(23.) When

(23.) When a geometrical figure contains five equal sides and angles, as the figure A, such a figure is called a pentagon; and if six as B, a hexagon; if seven as C, a heptagon; if eight as D, an octagon; if nine as E, a nonagon; and if ten as F, a decagon.

(24.) The diagonal lines of a geometrical square, are two right lines, drawn from one angle to the other, as the lines A B and C D.

(25.) The diameters of a geometrical square, are two right lines drawn through the intersection of the diagonals, parallel to the sides of the square, as the lines E F and I K.

(26.) The center of a geometrical square, is a point of intersection of the diagonals, or diameters, or both, it being the same as the point L. And what is here said of a geometrical square, the same is to be understood of an oblong, or parallelogram, rhombus, rhomboides and trapezium.

(27.) As lines terminate superficial figures, so do superficial figures solid bodies.

(28.) A solid body hath three dimensions, viz. length, breadth, and (thickness or) depth.

(29.) Geometrical solid bodies, are the sphere, spheriod, cone, frustum of a cone, cylinder, pyramis, frustum of a pyramis, prism, tetraedron, frustum of a tetraedron, cube, frustum of a cube, parallelepipedon, octaedron, dodecaedron, and icosaedron.

(30.) A sphere, globe, or ball, is generated by the revolution of a semicircle, about its own diameter. So also is a spheriod, by the revolution of a semi-ellipsis on its longest diameter, as figure A and B.

(31.) A cone, is generated by the revolution of a right angled plain triangle about one of its legs, as the figure D. So also is a cylinder by the revolution of a parallelogram about one of its sides, as the figure E.

(32.) The frustum of a cone, is the remains of a cone, when a part thereof is taken away from the upper part, as F L G, taken away from H L I, leaves the frustum F G H I; and what is here said of the frustum of a cone, the same is to be understood in the frustum of a pyramis or pyramment.

(33.) A pyramis, or pyramment, is a solid, which hath a triangle, square, polygon, &c. for its base, and hath as many reclining faces as are sides contain'd in the base, which all terminate in a point like a cone, which point, or termination, is called the vertex, or vertical point of the pyramment

pyrament or cone. See figure K, which is a pyrament, whose base is a geometrical square.

(32.) A prism is a solid body of five faces, three of which are parallelograms, and two equilateral triangles, as the figure M.

(33.) A tetraedron is a solid, containing four faces, each an equilateral triangle, and is one of those five bodies, as are called, the regular, or platonick bodies, as the figure N.

(34.) The frustum of a tetraedron is a tetraedron with the angles or vertexes cut off, or a small tetraedron cut from every angle. This body thus cut, is composed of eight faces, *viz.* four hexagons, and four equilateral triangles, and is as agreeable a body as any herein contained. See figure O.

(35.) A cube is a solid body containing six faces, each a geometrical square, as figure P.

(36.) The frustum of a cube, is a cube with the angles cut off, or 'tis a cube, that has had a pyramis cut from each angle, this solid contains fourteen faces, of which six are octagons, and eight equilateral triangles, which being taken together is a very handsome body. See figure Q. There is also another body, as is not a great deal different from the preceding, which by workmen is called the canted cube, and is no other than the greatest pyrament, as can be taken from each angle, (which in the former was not.) This body thus cut, contains the same number of faces as the preceding; but instead of having six octagons and eight small triangles, it hath six geometrical squares, and eight very large equilateral triangles. See figure U. Fig. XVI.

(37.) A parallelepipedon is a solid body, containing six faces (as the cube) whereof but two are geometrical squares, and the other four, parallelograms; but a parallelepipedon may have all its faces parallelograms, when its ends are parallelograms, instead of geometrical squares. See the figures R and S.

(38.) An octaedron is a solid body, containing eight faces, each an equilateral triangle.

(39.) A dodecaedron is a solid body, containing twelve faces, and each a pentagon.

(40.) An Icosaedron is a solid body, containing twenty faces, and each an equilateral triangle.

(41.) The basis of a sphere, or spheriod, is but a point.

(42.) The basis of a cylinder is a right line.

C

(43.) The

(43.) The basis of a cone is a circle.

(44.) Besides the preceeding solids there be two others, viz. one of twelve faces, and another of thirty, and every one a rhombus or diamond form. And as these definitions are full sufficient for any surveyor, I shall now proceed to the second section.



S E C T. II.

Of Geometrical Problems.

PROBLEM I.

TO divide the right line A B, into two equal parts, by the perpendicular d d.

Open your compasses to any distance, that is more than half the line A B. Place one foot or point in A, and with the other describe an arch as *e e*, then with the same opening on B, describe the arch *c c*, which will intersect the first arch *e e*, in *d d*; draw a right line from *d* to *d*, the two intersections, and it shall divide the given line A B, into two equal parts, in the point E, and shall be perpendicular thereunto.

Fig. XVII. A perpendicular is a right line, erected upon a right line, making the angles equal on each side, as E *d*, on either side A B.

Use.

This problem is of great use in the setting out of buildings and gardens, as well as in drawing or designing the same on paper. In the practice of which, a ten foot rod, or a garden line, supplies the place of compasses, for to describe the arches of intersection.

PROBLEM II.

Upon any point as E, given in the right line A B, to erect the perpendicular I E.

1. Open your compasses to any small distance, and placing one foot in the given point E, with the other foot intersect the given line on each side, as at *c* and *d*.

2. Open your compasses to any greater distance, and placing one point in *d*, with the other describe the arch

b b;

$b b$; also with the same opening on the point e , describe the arch $a a$, intersecting the first arch $b b$, in the point I . Fig. XVIII.

3. Draw the line $I E$, and it shall be the perpendicular required.

Use.

This is also a very useful problem, as also are all the ensuing, both in building and gardening, in dividing of the parts thereof, which are too numerous to be inserted here, and therefore are omitted till a more convenient time, when I shall present the world with a particular discourse on that subject for the instruction of such youth, whose natural genius tends either to architecture or gardening.

PROBLEM III.

From the end of the right line $A C$, at C , to erect the perpendicular $C D$.

1. Open your compasses to any distance, and set one foot in C , describe the arch $B n m$, and upon it set the same opening from B to n , and from n to m . Fig. XIX.

2. With the same distance, or opening of your compasses, describe the arch $n f$, on the point m , and also the arch $e m$, on the point n , intersecting the arch $n f$, in the point D .

3. Draw the right line $C D$, and it shall be the perpendicular required. This problem may be performed many other ways; but none better or easier than the preceding and the following.

PROBLEM IV.

How to erect a perpendicular upon the end of a line, after another manner.

1. With any opening of the compasses, describe the arch $B g$, on the point C , and set that opening from B to g .

2. Describe the arch $B D E F$, on the point g , with the same opening as before; and upon this arch set up the same opening three times, *viz.* from B to D , from D to E , and from E to F . Fig. XX.

3. Draw a right line from F to C , and it shall be the perpendicular required.

PROBLEM

PROBLEM V.

To let fall a perpendicular line, from a point to a right line given.

☞ In the performance of this problem, there is two cafes. The first, is when the given point is over or near the middle of the line. And the second, when near or over the end of the line.

Cafe I.

Let NO, be the right line given, and from the point P to let fall the perpendicular PQ.

1. Open your compasses to any distance greater than P Q, and on the point P describe the arch RS, intersecting the given line in the points R and S.

2. With any opening on the point R describe the arch *vv*, and with the same opening on the point S describe the arch *mm*, intersecting the first arch, in the point I.

3. Lay a ruler from I to P, and draw the right line PQ, and it will be the perpendicular required.

Cafe II.

Let T, O, be the right line given, and from the point V to let fall the perpendicular VM.

Fig. XXII. 1. From the given point V, to any part of the given line T O, draw a right line as VN, and by the first hereof divide it into two equal parts in the point X.

2. On the point X with the distance VX or XN, describe the arch or semicircle VMN, intersecting the given line in the point M.

3. From the point given, to M the intersected point, draw the right line VM, and it shall be the perpendicular required.

PROBLEM VI.

To describe a right line, parallel to a right line at any distance assigned.

Definition.

Parallel right lines are such, that being infinitely continued would never meet.

Of parallel lines there be principally two kinds, *viz.* right lined parallels and circular parallels, as in the following problems.

In describing of right lined parallels, there are two cases; the first, to draw a right line parallel to a right line at any distance given; the other, thro' a point assign'd, which point may be over, under, or oblique to the given line.

Case I.

Let EF be a right line given, and let it be required to draw another right line parallel thereunto, at the distance of GH. Fig. XXIII.

1. Take in your compasses the given line GH, and on any part of the given line EF, as at E, describe the arch *ik*, as also towards the other end, as at F, with the same distance, describe the arch *cm*.

2. A line drawn by the convexity of those two arches, shall be the parallel required, at the parallel distance of GH.

Case II.

Let AB be a right line given, and let it be required to draw another right line parallel thereunto; that shall pass thro' the point E.

1. Take with your compasses the nearest distance from the given point E, to the given line AB, and with that distance, at the end A, describe the arch *nn*. Fig. XXIV.

2. A right line drawn through the given point E, by the convexity of the arch *nn*, shall be the parallel desired, at the parallel distance of the given point E.

PROBLEM VII.

To make the angle MCB, equal to the given angle EAN.

1. Upon the angular point A, with any opening of the compasses, describe the arch *oo*, and with the same opening set one point, or foot of the compasses, on the point C, and describe the arch *nn*. Fig. XXV.

2. Take the distance *oo*, and set it from *n* to *n*.

3. A line being drawn from C to *n*, shall make the angle MCB, equal to the angle EAN, as required. This problem is of great use in taking the plan of buildings, gardens, &c.

PROBLEM VIII.

To divide an angle, as A B C, into two equal parts.

1. Upon the angular point B, with any opening, describe the arch *rr*, intersecting the sides of the angle in the points *rr*.
 Fig. XXVI. 2. With any opening, on the points *rr*, describe the arches *mm* and *vv*, intersecting each other in the point L.
 3. A right line drawn from L to B, shall divide the angle A B C, into two equal parts as required.

PROBLEM IX.

To divide a right line into any number of equal parts.

Let it be required to divide M N into fix equal parts.

1. From the end M or N, draw a right line at pleasure, as A M.
 Fig. XXVII. 2. Make the angle N M E equal to M N A, by Prob. VII. or by the second case of Prob. VI. make M E parallel to A N.
 3. Open your compasses to any small distance at pleasure, and set off that distance five times from N towards A, and from M towards E, as at the points 1, 2, 3, 4, 5.
 4. Draw right lines from 5 to 1, from 4 to 2, from 3 to 3, from 2 to 4, and from 1 to 5; and their intersections will divide the given line M N, into fix equal parts, as required.

PROBLEM X.

To find a mean proportion between two right lines given. Let it be required to find a mean proportion, between the given lines N and O.

1. Make A D, equal in length to both the lines O and N, and by Problem I. divide it into two equal parts, in the point C.
 F. XXVIII. 2. On the point C, describe the semicircle, making the diameter equal to A D.

Of Geometrical Problems.

11

3. At E (the joining of both lines) erect the perpendicular E I, and continue it till it meet the curve in the point I.

4. The line E I is the mean proportion required.

PROBLEM XI.

To find the center of a circle as shall pass through any three points given, as are not in a right line.

Let the three given points be D B A.

1. Draw a right line from any one of the points, as A, to either of the other points, as to B, and also draw another right line from B to D.

2. By problem I. divide those two equal parts by two perpendiculars, as the perpendicular lines H F and C E, which perpendicular lines do always intersect each other, and the point of intersection is the center of a circle as will pass through the points assigned. Fig. XXIX.

PROBLEM XII.

To inscribe a triangle geometrical square, pentagon, hexagon, heptagon, octagon, nonagon, or decagon, within a circle.

1. Describe the circle A F C G, and draw the diameter A C and F G, intersecting each other at right angles, in the center E.

2. Make A B and A D, equal to the semidiameter E C, and draw the right line B D, which is the side of an equilateral triangle, as may be inscribed in that circle.

3. Draw the right line A F, and it shall be the side of a geometrical square.

4. Upon H, with the distance H F, describe the arch F I, and draw the right line F I, which is the side of a pentagon as may be inscribed therein. The diameter A C, or F G, is the side of a hexagon, and half B D; as H B, or H D, is the side of a heptagon or septagon. Fig. XXX.

5. From E, the center through M, draw the right line E M K, so shall the distance, or right line A K, be the side of an octagon.

6. Divide the arch B A D, into three equal parts, each of which is the side of a nonagon, as D S.

7. The distance E I is the side of a decagon. Every side in the figure is number'd with its proper number,
as

Of Geometrical Problems

as the side of a pentagon with number 5, a hexagon with the number 6, &c.

This figure, thus made, is a very useful instrument to inscribe any polygon in a circle, when required; as for example:

Let it be required to inscribe a nonagon in the circle A B C D.

- Fig. XXXI.
1. On the center E, describe the circle F, G, H, I, equal in diameter to the circle A F C G, fig. XXX.
 2. From thence take the distance S D, and set that distance from F to V, from V to Q, from Q to P, &c. to the point F, where you began.
 3. Lay a ruler from the center E, to the several points F V Q P, &c. and 'twill cut the outer circle in the points *x x x*, &c.
 4. Draw lines from *x* to *x*, &c. and those lines shall form the nonagon required. And what is here said of a nonagon, the same rule is to be understood of any other figure, as before described.

PROBLEM XIII.

To make an equilateral triangle, as A, B, O, whose sides shall be equal to any given line, as the right line N M.

1. Make A B equal to the given line N M, and with the distance A B, on the point A, describe the arch *v v*, and with the same distance on the point B, describe the arch *a a*, intersecting the arch *v v*, in the point O.
 2. Draw from the intersection O, the right lines A O, and B O, and they will complete the equilateral triangle whose sides are each equal to the given line N M, as required.
- F. XXXII.

PROBLEM XIV.

Three unequal right lines, as R S T, being given to make a right lined triangle, whose sides shall be equal thereunto.

1. Make A B, equal to R.
2. Take the line S in your compasses, and on A. describe the arch *a a*.

I

3. Take

3. Take the line T in your compasses, and on B describe the arch *m m*, intersecting the first arch in the point C.

Fig.

4. Draw from the intersection C, the right lines C A and C B, and they will complete the triangle, whose sides are respectively equal to the given line R S T, as required.

$$\left. \begin{array}{l} A B \\ A C \\ C B \end{array} \right\} \text{equal to the given line} \left\{ \begin{array}{l} R \\ S \\ T \end{array} \right.$$

PROBLEM XV.

To describe a geometrical square, whose sides shall be equal to a right line given.

Let it be required to make the geometrical square M N O P, whose sides shall be respectively equal to the given line A B.

1. Make O P equal to A B.

2. On the point P erect the perpendicular P N, (by problem III, or IV, hereof) and make it equal in length to the given line A B.

Fig.
XXXIV.

3. With the distance A B, on the point N, describe the arch *n n*, and with the same distance, on the point O, describe the arch *a a*, intersecting the former in the point M.

4. From M the point of intersection, draw the right lines M N and M O, and they will complete the geometrical square, as required.

PROBLEM XVI.

To make an oblong parallelogram, or long square, as A B C D, whose length and breadth shall be equal to two given lines, as N O.

1. Make the line C D, equal to the given line O, and on D, (by the III^d problem hereof) erect the perpendicular B D, and make it equal to the given line N.

Fig.
XXXV.

2. On B, with the distance C D, describe the arch *o o*, and on the point C, with the distance B D, describe the arch *r r*, intersecting the former in the point A.

Of Geometrical Problems.

3. From A the point of interfection, draw the right lines A B and A C, and they will complete the oblong, as required

The fide A B and C D } is equal to the right line { O
The fide A C and B D }

PROBLEM XVII.

To make a rhombus, or diamond form, whose sides shall be equal to a right line given.

Let it be required to describe the rhombus A, M, N, O, whose sides shall be each equal to the given line V, R.

Fig.
XXXVI.

1. Make A O equal to V R, and on the point O, with the distance O A, describe the arch A M N.
2. With the same distance set up the opening of the compasses from A to M, and from M to N.
3. From the point A to the point M, draw the right line A M, and from the point M, draw the right line M N to the point N; and lastly, draw the line N O, and you will complete the rhombus as required, with its respective sides equal to the given line V R.

PROBLEM XVIII.

To make a rhomboyades, whose sides shall be equal to two given right lines, as L and Q; and the acute angles at M and O, equal to the given angle Z.

Fig.
XXXVII.

1. Make P M equal to the given line L, and by problem VII, make the angle E M P, equal to the angle Z, and make M E equal to the given line Q.
2. Take in your compasses the given line L, and on E, describe the arch *u u*.
3. Take the length of the other given line Q, and on the point P, describe the arch *a a*, intersecting the former in the point O.
4. From O the point of interfection, draw the lines O E and O P, and they will constitute the rhomboyades as required, whose sides O E and P M, shall be equal to the given line L, and the sides O P and E M, equal to the given line Q, as also the angles at O and M, equal to the given angle Z.

PROBLEM

PROBLEM XIX.

To make a trapezium (as the figure R N O M) whose sides shall be equal to four right lines given, as the lines D, E, V, T, and one angle, as the angle N, equal to an angle given, as the angle Z.

1. Make N M equal to the given line D, and by problem VII. make the angle at N, equal to the given angle Z, and make N, R, equal to the given line E.

2. Take the given line V in your compasses, and on M describe the arch *n n*, then take the given line T, and on R describe the arch *a a*, intersecting the former arch in the point O.

Fig.
XXXVIII.

3. From the point of intersection O, draw the right lines O M and O P, and they shall complete the trapezium, as required, with its respective sides equal to the lines given.

PROBLEM XX.

How to describe an ellipsis to any length and breadth given, as the figure A B C M, whose longest diameter is equal to the given line D V, and the shortest to the line E P.

1. Make the right line A C equal to the given line D V, and (by problem I.) divide it into two equal parts, by the perpendicular B M, which make equal to the given line E P.

2. Take half the longest diameter, as A F or C F, and on B describe the arches *a a*, and *a a*, intersecting the longest diameter in the points O and N, which are the two centers by which the ellipsis may be described.

Fig.
XXXIX.

3. Fasten two pins, or tacks, (if on the ground, as in a garden, two stakes) at O and N, and putting a line about them, fasten the ends together, at the length of the line O C, or N A, so that the string may move about both the pins, tacks, &c. at pleasure.

4. Take a black-lead pencil, tracer, &c. and extending the line therewith, it will, by its motion about those two centers, describe an ellipsis, as shall be equal in length and breadth to the given lines D V and E P, as required.

PROBLEM XXI.

How to describe an ellipsis to any length and breadth, as the figure A B C D, whose longest diameter is equal to the given line M, and the shortest to the line N, by the help of a pair of compasses, without the assistance of a line and tracer, as in the preceding problem.

Fig. XL.

1. Describe the longest and shortest diameters, equal to the given lines, intersecting each other, at right angles in the point E (as in the preceding).
2. Take half the shortest diameter, as B E, and place that distance from A to F on the longest diameter.
3. Divide the space between F and E the center, into three equal parts, and place one of those parts backward from F to I.
4. Make E K equal to E I, and on K, with the distance K I, describe the arches *nn* on the one side, and *nn* on the other.
5. With the same distance, on the point I, describe the arches *o, o*, and *o, o*, intersecting the other two in the points L and M.
6. Lay a ruler from L to I, and draw the line I V; also from L to K, and draw the K P; also from M to K, and draw the line K Q; and also from M to I, and draw the line I R.
7. On I, with the distance, I A describe the arch *z A z*, and on K, with the same opening, describe the arch *x C x*.
8. On M, with the distance M z, describe the arch *z B x*; and on L, with the same opening, describe the arch *x D z*, and thus is the ellipsis completed, as required.

PROBLEM XXII.

To inscribe a circle within a square.

Fig. XLl.

- 1 Draw the diagonals N S and V M, intersecting each other in the point O.
2. From the point O, let fall the perpendicular O C, and with the opening O C on O, describe the circle as required.

PROBLEM XXIII.

To inscribe a square within a circle, and to circumscribe a circle about a square.

1. By the third of problem XII. inscribe the square A E I O, and draw the diagonals A O and E I, intersecting each other in the point N. Fig. XLII.

2. On N, with the distance N A, N E, N I, or N O, (they being all equal to each other, by definition II. fig. VII.) describe the circumscribing circle, as required.

PROBLEM XXIV.

To inscribe a circle within a triangle, as the circle M, o, e, within the equilateral triangle A E N.

1. Divide any two of the angles of the given triangle, as the angle N and A, into two equal parts, by the lines N o and A e, intersecting each other in the point M, (as by problem VIII. hereof). Fig. XLIII.

2. From M let fall the perpendicular M P; and on M, with the distance M P, describe the inscribed circle, as required.

PROBLEM XXV.

To circumscribe a circle about a triangle.

The solution of this problem is exactly the same as problem XI. For if you suppose the three angular points B C A, to be three given points, &c. as in that problem, the operation hereof is exactly the same, and therefore needs no further demonstration. Fig. XLIV.

PROBLEM XXVI.

To find the center of a circle, that shall pass through any two given points within a circle, and divide the circumference into two equal parts.

Let M N be the given points.

F

1. From

Fig. XLV.

1. From any one of the points as M, draw a right line through the center O, extending it infinitely to $\mathcal{A}\mathcal{E}$. Upon this line, at the center O, erect the perpendicular O W, and from W through M, draw the line W R; and from R, through O the center, draw the diameter R, O, a.

2. Draw the right line W a, and extend it till it intersect the line M O $\mathcal{A}\mathcal{E}$, in the point V; through which, and the given points M and N, you may describe the arch of a circle (by problem XI.) as will divide the circumference given into two equal parts, and pass through the two given points, as required.

PROBLEM XXVII.

To make a geometrical square, as A E M N, equal in area to any right lined triangle, as the triangle I O M, given.

Fig. XLVI.

1. Let fall the perpendicular O R, and make M S equal to half the perpendicular O R.

2. Divide I S into two equal parts at R, and on R, with the distance I R, or R S, describe the semicircle I A S.

3. At M erect the perpendicular M A, and extend it till it intersect the semicircle in A.

4. The line A M is the side of a geometrical square, whose area is equal to the area of the triangle given, as required.

PROBLEM XXVIII.

To make a geometrical square, equal to a parallelogram given.

Fig. XLVII.

Let it be required to make a geometrical square equal in area to the oblong, or parallelogram, A B C D.

1. Continue the side C D to F, making D F equal to B D, and divide C F into two equal parts at G, and thereon, with the distance G C, or G F, describe the arch C E F.

2. Continue D B to E, and then will D E be a mean proportional, and the side of a geometrical square, whose area is equal to the oblong, or parallelogram, A B C D given, as required.

PROBLEM

PROBLEM XXIX.

To divide a line given, in such proportion as another is before divided.

Let it be required to divide the right line M, in such proportion as the line A E.

1. By problem XIII. hereof, make the equilateral triangle G H I, with its sides equal to the line A E, and divide any one side thereof, as H I, in the same proportion, as A E (the length being equal).

2. Take the length of the line M, and set it from G (the angle opposite to the side divided) to V, on one side, and to O, on the other side, and draw the right line V O. Fig. XLVIII.

3. Lines being drawn from G, thro' the points 1, 2, 3, 4, 5, and 6, shall intersect the line V O, in the points o o o, &c. and divide that line in the very same proportion as the given line H I, as was required.

PROBLEM XXX.

To divide the circumference of any circle into 360 equal parts, as the circle A B C D, fig. XLIX.

1. Draw the diameter A C, and by problem I. divide it into two equal parts by the perpendicular B D, then will the circle be divided into four equal parts, and consequently the circumference also.

2. Open your compasses to half the diameter, as P A, &c. and set that distance, *first*, from A to e, and from A to f; *secondly*, from B to m, and from B to l; *thirdly*, from C to k, and from C to i; *lastly*, from D to h, and from D to g; and thus you have divided the circumference into 12 equal parts, each representing 30 degrees.

3. Divide each of those divisions into three equal parts, and each of those parts into ten, and then will the circle be divided into 360 equal parts, which are called degrees. It is to be observed herein, that the semi-diameter, which is generally called the radius, is always equal in length to 60 degrees, or equal parts of the circumference. Every equal part (or degree) of the circumference, is always supposed to be divided into 60 lesser equal Fig. XLIX.

Of Geometrical Problems.

qual parts, and those are term'd or called minutes. Therefore when we mention two degrees and a half, we say two degrees 30 minutes; or one deg. and $\frac{1}{2}$, we say one degree and 20 min. and when we write down any number of degrees and min. as thirty degrees fifty seven minutes, we write them thus $30^{\circ} : 57'$, &c. And what is here said in the division of the circumference of this circle, the same is to be understood in the division of the circumference of every circle, for in the circumference of every circle, there is always the same number of degrees therein, although some circles may be smaller, and others larger than the given circle A B C D.

Demonstration.

1. Draw right lines from the center P, through every tenth degree of the circumference, and extend them infinitely.

2. On P the center, describe the inward circle, and the lines before drawn through every tenth degree, will intersect that circle in the points *n n n*, &c. and will divide that circumference into thirty six equal parts, each representing 10 degrees. Also on P describe the outward circle *o o o o*, &c. wherein you may observe the afore said lines of every tenth degree, to divide that circumference in the very same proportion, as the inward circle *n n n n*, &c. and the given circle A B C D. Therefore let any circle be as small as may be conceived, or as large as the greatest circle as can be supposed to bound the universe, the number of degrees in each are both equal, and consequently the minutes the same, though greater or lesser each, in such proportion as the circumference of one circle hath to another, which is what was to be demonstrated.

Fig. XLIX.

N. B. Before the young student proceeds any further, let him well understand this problem, for hereon the whole body of mathematicks depends, as also the several operations following; but if he finds any difficulty upon the first or second reading, either of this or any other problem, let him not be discouraged, 'twill by often contemplating be made easy; for mathematicks, is not to be understood at once reading over, like plays, history, or romances.

PROBLEM XXXI.

To inscribe an ellipsis within an oblong, or parallelogram, as A B C D.

1. Draw the two diameters of the parallelogram, as E G and F H, which suppose to be the length and breadth of an ellipsis given, to describe the same as if they had not been the diameters of the oblong. Fig. L.

2. By problem XX, or XXI, describe the ellipsis E F G H, and it will be the ellipsis inscribed, as required.

PROBLEM XXXII.

To erect a perpendicular line by the help of a ten foot rod (or other measure equally divided) on the ground, in the setting out of a building, garden, &c.

The proportional numbers contained in a square, or right angle, is 3, 4, and 5; or 6, 8, and 10; therefore if you would raise the perpendicular D F, from the point D, on the line H D; set off six foot from D to E, and with eight foot of your rod at D, describe the arch *a a*; and also with ten foot, describe the arch *B B*, on the point E, and the intersection F is the perpendicular point required: or, from E lay a ten foot rod, and from D an eight foot rod, and close their ends together, and that shall be the perpendicular point also; and a right line drawn from thence to D, shall be the perpendicular required.

This problem may be applied to practice on paper, if you use a scale of equal parts, and a pair of compasses instead of the ten foot rod.

S E C T. III.

Of Geometrical Axioms and Theorems.

P L A T E IV.

A X I O M I.

[F to, or from, equal quantities, be added or subtracted equal quantities, the sums or remainders will be equal.

Demonstration.

Fig. I.

1. Draw the two diameters A F and L B, intersecting each other in the center N, and then will the angle A N L be equal to the angle B N F, for the arches A B and B F completes a femicircle, as also do the arches B A and A L. Therefore the arch B F must be equal to the arch A L, because the arch A B continues the same; and by the same reason the angle A N B, is equal to the angle L N F.

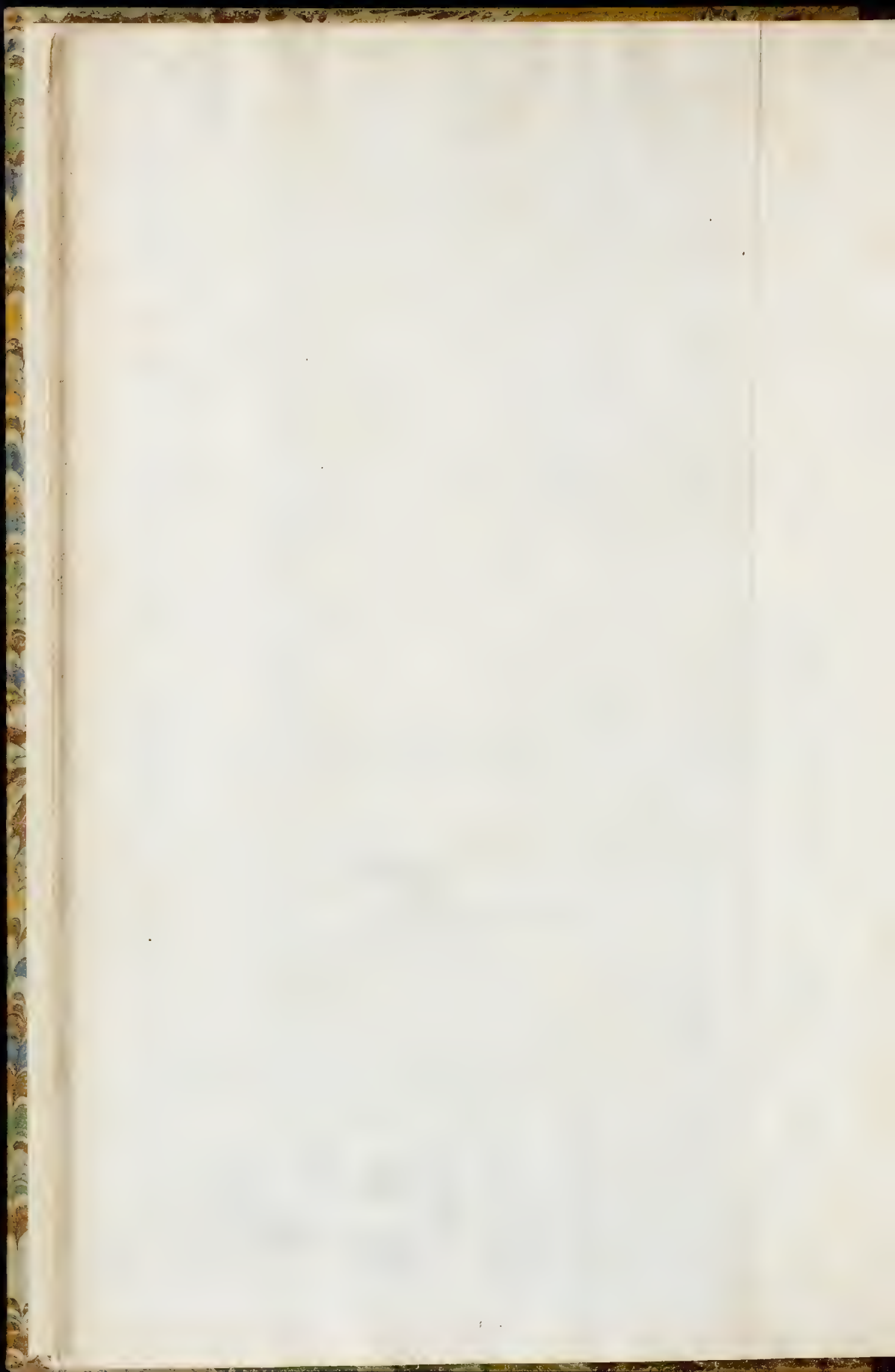
A X I O M II.

Quantities equal to a third, are equal to one another.

Demonstration.

Fig. II.

The alternate angles C and F, are equal to each other, as also E and D; for the angle C is equal to the angle B, and the angle B to the angle F, by the preceding axiom. Wherefore C and F being both equal to B, must be equal to one another, and the like of E and D, which are both equal to the angles A and G.



THEOREM I.

If a right line do fall on two parallel right lines, it maketh the opposite angles equal, and the internal angles on the same side, equal to two right angles, or 180 degrees. Fig. II.

1. The right line P Q, falling upon the two parallel right lines R T and S V, do make the angle D equal to A, and C to B, also the angle G equal to E, and H to F.

2. the angle D with F is equal to two right angles, because F is equal to C (by axiom II.) and C and D together are equal to two right angles, or a semicircle; and since the angle F is equal to the angle C, therefore F D or E C, are equal to two right angles, or 180 deg. which was to be proved.

THEOREM II.

If multifarious right lines be intersected by multifarious right lines, which are parallel one to the other, the segments are proportional one to the other. Fig. III.

Demonstration.

Let the right lines N O and N M, be intersected by the six parallel right lines T T, V V, X X, Y Y, Z Z, and W W; then will the intersegments be proportional one to the other. For if N A be one fifth part of N O, N B is likewise one fifth part of N M, and the like of all others.

THEOREM III.

If four right lines be proportional, that is, as the first is to the second, so is the third to the fourth; the parallelogram made of the two means (or middle terms) will be equal to the parallelogram made of the extremes. Fig. IV.

Demonstration.

Let the four proportionals be A 24, B 16, C 12, and D 8; I say, the parallelogram made of the two mean terms,

Of Geometrical Axioms and Theorems.

terms, *viz.* 16 and 12 is equal to the parallelogram made of the two extrems, *viz.* 24 and 8. Therefore multiply 16 by 12, and the product is equal to 192, and also 24 by 8, and the product is equal to 192, as before. Therefore 'tis apparent, that the parallelogram made of the means, is equal in power to the parallelogram made of the extrems, which was to be demonstrated.

THEOREM IV.

If three right lines be proportional, viz. as the first is to the second, so shall the second be to a fourth. The square made of the means shall be equal to the oblong made of the extrems.

Demonstration.

Fig. V.

Let the proportional lines or numbers be 4, 8, 8, then will it be as 4 is to 8, so is 8 to 16, and the square A E I O of the means, will be equal to the parallelogram, made by the extrems. For multiplying the means 8 by 8, the product is 64, and multiplying the extrems 4 and 16 by each other, the product is 64, and is equal to the product of the means which was to be demonstrated.

THEOREM V.

In every right angled plain triangle, the square made of the hypotenuse, or side which is opposite to the right angle, is always equal to the sum of the squares made of the legs or sides.

Demonstration.

Fig. VI.

Let N O M be a right angled plain triangle, whose sides are as follows, *viz.* the side N M equal to 6, and the side M O equal to 8, then will the hypotenuse be equal to 10.

2. If you multiply the side N M into itself, its product will be equal to 36, the square N D M I.

3. Multiply the side M O into itself, and its product will be equal to 64, the square M O V C.

4. Add

4. Add the area of both squares together, *viz.* 36 and 64, and their sum will be equal to 100.

5. Multiply the hypotenuse NO into itself, and its product is 100, which is equal to the sum of the squares made of the legs before added together, as was to be demonstrated



SECT. IV.

PLATE. II.

Of the *Construction* of Compound Geometrical FIGURES.

I. General AXIOMS for the proportions of figures.

AXIOM I.

THat the length of a proportionable parallelogram be to the breadth, as three is to two; therefore if the length be three foot, the breadth must be two foot.

AXIOM II.

When a geometrical square hath its sides intercepted with semicircles externally, as A, the diameter of every such semicircle must contain $\frac{2}{7}$ of the side, on which 'tis described; and the same proportion also, when at the end of a parallelogram, as B.

Fig. IX.

AXIOM III.

When the angles of a geometrical square, or oblong, is cut off by the arch of a circle, the radius of those quadrants, or arches, must be $\frac{1}{7}$ the length of the side of a geometrical square, or end of the parallelogram, and the same proportion is to be observed when the angles are
H cut

Of the Constitution of

cut off by a small geometrical square, as the fig. C cut by little squares, and D by quadrants or arches.

Axiom IV.

When the side of a geometrical square, or end of a parallelogram, hath its angles cut off by arches or little squares, and the $\frac{1}{2}$ remaining be intercepted by a semicircle, as EF; the arches, or little squares, must be first described, and the diameter of the semicircle must contain $\frac{1}{2}$ of the remainder, as the semicircle in axiom II. contains $\frac{1}{2}$ of the whole breadth.

Axiom V.

When the angle of a geometrical square, or oblong, is cut off by a part of a geometrical square, and the quadrant of a circle, as fig. G; the radius of those arches, or quadrants, must contain $\frac{1}{4}$ of the side of each little square.

Axiom VI.

Fig. IX.

When a compound figure is circumscribed by a compound figure, those arches of the compound figure circumscribing, must contain $\frac{1}{3}$ of that side to which they belong, so *a, b*, contains $\frac{1}{3}$ of CD in figure H; but the center of all such arches must always be upon the internal fig. as at *m*.

Axiom VII.

When any side of a right line figure has a square break therein, as the figure T at V; the length of that break must be $\frac{2}{5}$ of AB, (*viz.* the length of the side wherein it stands) and the depth $\frac{1}{5}$; but when a break happens against an arch, as at O, in figure TT, those breaks must be made in proportion to the curve of the opposite arch.

Axiom VIII.

When an arch breaks into an oblong, as the arches *mm* in figure TT, it must not break in above $\frac{1}{5}$ of the breadth of the oblong at most, and the extremities of such an arch must ever be five times their depth. They are
to

to be described by problem XI. sect. I. having the depth, and both extrems given, as three given points.

AXIOM IX.

When the sides of a geometrical square is intercepted with semicircles internally, as figure Z; the diameters of those semicircles must be no more than one half the side of the square, wherein they are described.

Fig. IX.

These axioms, and the preceding problems of sect. I. being well understood, the young student will find no sort of difficulty in describing the figures contain'd in the eight ensuing problems, to which we will proceed

A general Rule concerning Compound Figures.

THAT every compound (or plain) figure, that is encompass'd with another figure, be not of the same kind, viz. not to encompass an octagon with an octagon, but with a circle, or some other figure as is agreeable thereunto, and the like of all other figures in general.

PROBLEM I.

To describe the compound figure A B C D, with its circumscribing figure E F G H.

1. By problem XV. sect. I. describe the geometrical square A B C D.

Fig. I.

2. By axiom II. hereof, describe the quadrants of each angle, and thus will the interior figure be completed.

3. At the parallel distance assign'd, draw the square E F G H, by problem VI. sect. I. and by axiom VI. hereof; describe the arches o, o, o, o , whose centers are at e, e, e, e , and they will complete the figure required.

Of the *Construction* of

PROBLEM II.

To describe the compound figure A B C D, with its circumscribing figure E F G H.

- Fig. II. 1. By problem XV. sect. I. describe the square ABCD, in such proportion as is laid down in axiom I. hereof, and by axiom III. deduct the little squares from every angle.
2. Describe the outer parallelogram parallel to the first at the distance assign'd, and by axiom VI. describe the four arches H, G, F, E, whose centers are at *a a a a*, and they will complete the figure required.

PROBLEM III.

To describe the compound figure A B C D, with its circumscribing figure.

- Fig. III. 1. By problem XV. sect. I. describe the geometrical square ABCD, and by axiom II. hereof, describe the semicircles, and then by drawing the circumscribing line parallel thereunto, at any distance assign'd, the figure is completed as required.

PROBLEM IV.

To describe the compound figure A B C D, with its circumscribing figure.

- Fig. IV. 1. By problem XVI. sect. I. describe the parallelogram, according to the proportion of axiom I.
2. By axiom III. cut off the angles with the quadrant of a circle, and by axiom II. describe the semicircles at each end, whose centers are *e e*.
- Lastly*, Describe the circumscribing figure parallel thereunto, at any distance assign'd; and the figure is completed, as required.

PROBLEM V.

To describe the compound figure A B C D, with the circumscribing figure E F.

1. By

1. By problem XVI. sect. I. describe the parallelogram A B C D, according to the proportion of axiom I. and describe the semicircles at the ends, according to axiom II. Fig. V.

2. Describe the outward line parallel thereunto at any distance assigned; and by axiom VII. describe the breaks E F, and the figure is completed as required.

PROBLEM VI.

To describe the compound figure A B C D, and its circumscribing figure E F G H.

1. By problem XV. sect. I. describe the geometrical square A B C D, and by axiom V. describe the angles. Fig. VI.

2. At any assigned distance describe the outer square E F G H; and by axiom VII. describe the quadrants at every angle.

Lastly, By axiom VI. describe the arches K M N L, and the figure is completed as required.

PROBLEM VII.

To describe the compound figure A B C D, and its circumscribing figure E F G H.

1. By problem XV. sect. I. describe the geometrical square A B C D, and by axiom II. describe the semicircles whose centers are *a a a a*; and by axiom III. describe the arches at every angle. Fig. VII.

2. At any parallel distance assign'd, describe the square E F G H, and at the same parallel distance, describe the arches I K L M, and the figures will be completed as required.

PROBLEM VIII.

To describe the compound figure A B C D, with its circumscribing figure E K F L H M G I.

1. By problem XV. sect. I. describe the geometrical square A B C D, and by axiom IX. describe the semicircles *a a a a*. Fig. VIII.

2. At any parallel distance assigned, describe the square E F G H; and by axiom VII. describe the breaks K L M I; and by axiom III. the arches at the angles E F G H, which will complete the figure as required.

These foregoing eight inscribed figures, are very beautiful forms for fountains, basons, fish-ponds, grass-plots, or ornaments of cockle-shells, sand, borders, &c. about a stately tree of yew, holly, philirea, laurustinus, &c. or statue. Provided that you have the advantage of a terrace-walk, or mount, to view the same, otherwise a plain plot of grass is far preferable.

And to complete the idea and practice of such figures in gardening, I have, for the exercise of the young student, and variety of choice, for all gentlemen as delight therein, inserted the several forms in figure X. which are in general described by the preceding rules, and may not only prove a great help to invention, but also of use to many gentlemen in forming such parts of their gardens (as they relate to) in the most elegant manner.

Fig. X.

Those figures marked A A, &c. are varieties of the interfections of gravel, sand, and grass walks with proper central plots, or figures, to place statues on pedestals in, as also the forms of the ends of parterres, or grass-plots, as circumscribe the same.

Those figures marked B B, &c. are niches, or breaks in hedges, walls, &c. for to place publick seats of delight in, at the termination of an elegant walk, avenue, &c. And,

Those marked D D, &c. are the forms of cabinets, or private places of retirement, in the most private retired parts of a wilderness, labyrinth, grove, &c.

N. B. That although hitherto I have recommended these compound figures in gardening only; yet the ingenious student in architecture is to observe, that they are exceeding beautiful in building, as in cielings, parquetting, painting, paving, &c.

S E C T. V.

Of the Construction of the single, double, &c. spiral Line, Scroll, Artinatural Line, &c. for Practice in Gardening.

P R O B L E M I.

P L A T E III.

T^O describe a single spiral line at any assigned distance.

Let it be required to describe the single spiral line, at Fig. I. the distance of the given line ik .

1. Draw a right line, as AB , and on any convenient point of the same, as at c , describe a circle of such a diameter as is assigned.

2. Take half the given line ik , and place that distance from c the center, to b and d on each side hereof, which points, b and d , are the two centers, on which the double spiral line will be described.

3. Take the distance da , and on d , describe the femi-circle af .

4. Take the distance bf , and on b , describe the femi-circle fb .

5. Take the distance db , and on d , describe the femi-circle bg ; and so by moving your compasses first to the other center b , and afterwards to d , &c. you may continue the spiral line about infinitely, which is what was required to be performed.

P R O B L E M II.

To describe a double spiral line at any distance assigned.

Let it be required to describe the double spiral line, Fig. II. at the distance of the given line m, n .

Of the Construction of the

1. Draw a right line, as A B, and on any convenient point of the same, as at *a*, describe a circle of such a diameter as is assign'd.

2. Take half the given line *m, n*, and place that distance from *a* the center, to *b* and *c* on each side thereof, which points, *b* and *c*, are two centers, on which the double spiral line will be described.

3. On *c*, with the distance *c, e*, describe the semicircle *e, s, d*.

4. On *b*, with the same distance, describe the semicircle *m, n, f*.

5. On *c*, with the distance *c f*, describe the semicircle *f r g*, and then you will have got the double line equal; therefore, if you remove your compasses to the other center *b*, you may thereon, with the distance *b d*, describe the semicircle *d, o, h*, and on the same center, the semicircle *g P i*, and then by removing again, first to *c*, may describe the semicircles *h, u, k*, and *i, Q, l*, &c. as in the preceding problem, which is what was to be demonstrated.

PROBLEM III.

To describe the compound line, called the running worm.

This line may be described in two manners, *viz.* on a right line, as A B, or on a spiral line, as N K I G E.

I. *To describe the running worm on a right line.*

Practice.

Fig. III.

1. Draw the right line A B, and on *a*, with any convenient opening (that will not describe an arch with too sharp a turning to create giddiness in walking) describe the arch A *b*, and with the same opening, turn your compasses from *b* to *c*, and on *c*, describe the arch *b d*; and then turning them *d* to *e*, describe the arch *d f*, and in the like manner all the others contain'd in the line A B. When this line is applied to any use as requires breadth, as a walk through a wood, &c. that breadth may be described upon the same centers, as the line it self, and in the very same manner.

II. *To*

II. *To describe the running worm on a spiral line.*

Practice.

1. By the preceding problem, describe the double spiral line $F G$, $H I$, $K L$, $M N$; and on $E a$, describe the semicircle, or rather arch $b c$, and on the same center, the arch d, e, f .

2. With the former opening $b a$, turn the compasses from c to g , and on g , describe the arch $c b$, and also the arch $f i$; and with the same openings and manner of working the other arches, and their parallels, must be described. And as this running worm is described but on one of the two spiral lines, therefore by giving the other the same parallel breadth as the running worm, and uniting them together at Z and F , 'twill create a variety in walking, and unexpectedly bring out the person, at his place of entrance, contrary to his expectation.

PROBLEM IV.

To describe a treble spiral line at any distance assigned.

Let it be required to describe the treble spiral line at the distance of the given line m, n ,

1. By problem XIII. sect. I. describe the equilateral triangle $A B C$, and make the sides thereof each equal to the given line m, n , and from the center thereof, through every angle, draw the right lines $B D$, $C D$, and $A D$.

2. On A , with the distance $A C$, describe the arch $c d e$, and with the same opening on B , describe the arch $A f g$; and also on C , describe the arch $B h i$. (And here you must note, that in this and all other figures of this kind, the several arches therein that compose the whole must not be continued in one arch of a circle any farther than from one line of direction to another, be there one, two, three, four, &c. viz. in this figure; for example, no arch must be described at one sweep, no farther than from the line of direction $A D$ to the line of direction $C D$, or from the line of direction $C D$ to the line of direction $B D$;
K and

and the like from the line of direction B D to the line of direction A D.

3. On A, with the distance A *i*, describe the arch *i k l*; and with the same opening on the point B, describe the arch *e m n*; and also on the point C, describe the arch *g o, p*.

4. On the point A, with the distance A *p*, describe the arch *p, t, u*; and with the same distance on B, describe the arch *l, q, u*; and also on the point C, describe the arch *n r s*; and in the like manner on the three points A B and C, you may encrease the magnitude thereof, as much as desired, which is what was required to be done.

These treble spiral lines, are exceedingly beautiful, when planted with hedges of hornbeam, english-elm, &c. and the whole environ'd with a wood, wherein may be described divers other walks (as those marked F F, &c.) that be made to unite with the three several walks of the spiral line, as at D D D.

Those walks marked F F, are what I call artinatural walks by reason they are described by art, and represent the product of nature, which in all woods and wilderesses should be imitated as near as possible, which hitherto, by designers of gardens, as the late Mr. *London*, his followers, &c. has never been thought of, or practised, they always observing a stiff heavy regular form equal in all other parts alike; so that when any person had seen one quarter of any of their gardens, they had then, in effect, seen the whole, the remaining three parts being but the first repeated so many times, and those stuff'd up with their ever-greens at such a rate, that they ever had an aspect more like unto a nursery than a pleasant garden, as intended.

The beauty of a garden (in my humble opinion) consists in a regular, irregularity, that the parts may appear as equal, and at the same time be unequal among themselves, and thereby, at every step forward, a new scene, or fresh object appears, and the whole becomes an everlasting entertainment.

But since this treatise is not particularly design'd for gardening, I shall therefore forbear, and return to problem V.

PROBLEM V.

To describe a quadruple spiral line at any distance assign'd.

Let it be required to describe the quadruple spiral line at the distance of the given line H I.

1. By problem XV. sect. I. describe the geometrical square 1 2 3 4, and make each side thereof equal to the given line H I.

2. Divide each side thereof into two equal parts, and draw the diameters, extending them infinitely; as from A the center, to B C D and E.

3. On A the center, describe the circle *e b c d*, of such diameter as shall be assign'd.

4. The points 1 2 3 and 4, being the centers on which the whole is described; therefore, on the point 1, with the distance 1 *d*, describe the arch *d a*; and with the same distance on 2, describe the arch *b f*; and also on 3, describe the arch *e g*; and likewise on 4, describe the arch *c h*. Fig. VI.

5. Begin again, and on the point 1, with the distance 1 *h*, describe the arch *b i*; and with the same distance on the center 2, describe the arch *a k*; and also on 3, describe the arch *f l*; and likewise on 4, describe the arch *g m*; and then beginning again at the center 1, with the distance 1, *m*, &c. you may describe the four lines to any magnitude required.

This kind of figure may at last be circumscribed in a circle (as in the figure) when 'tis applied to practice on the convexity of a mount, or concave, as that of the Honourable *Thomas Vernon's*, in the gardens of his seat at *Twickenham Park* in the County of *Middlesex*, made by me in the year 1722. This concave was a large sand-pit, and then a perfect nuisance, and supposed to be incapable of any improvement as would be agreeable to the circumjacent parts of the gardens, then new made: but when I deliver'd a draught of the same, the former supposition was destroy'd, and 'twas then demonstration sufficient, that instead of its being a nuisance, 'twould be a very agreeable beautiful figure, as it now appears in.

And from hence it further appears, that the great expence that many noblemen and gentlemen have formerly been put to, by the indiscreet directions of Mr. *London*, and his emissaries,

emissaries, in removing hills to fill up such concavities, to make the ground level and uniform (as they in their own terms call it) for the execution of their regular stuff'd up parterres, flower knots, &c. with fine finakin furbelow'd yews, hollies, &c. whereby the whole ever had the aspect of a nursery, more than a garden of delight, as I said before; were not only an immense needless expence, but the garden it self thereby totally ruin'd. And since I have here taken the liberty to mention that error, I will also enlarge a small matter further, in relation to another, full as gross as the preceding, *viz.* to fully execute their regular forms, cut down many a well grown sturdy oak, elm, &c. and introduces a trifling flowering shrub, or small tree of yew, holly, phylerea, laurustinus, &c. which, in my opinion, is a plain proof of their ignorance of the science, as well as a crime almost unpardonable. But to return to problem VI.

PROBLEM VI.

How to describe an elliptical spiral line about an ellipsis given.

Let it be required to describe about the ellipsis K M I L, the elliptical spiral line N O G P Q V R S T W E, at the distance of the given line X Y.

1. Describe the ellipsis K M I L, according to problem XXI. sect. I. and draw the lines of direction G F, G A, H C, and H E, infinitely.

2. Divide the given line X Y into nine equal parts, and take the distance of two of those divisions in your compasses, and set it on the line of direction G F, from D, the point of intersection, to 1, and on the same line from G to 2; as also from B to 3, and from H to 4, on the same line. These four points 1, 2, 3 and 4, are four centers, as will describe the elliptical spiral line, as following.

1. On the point 1, with the distance 1, N, describe the arch N, O.

2. On 4, with the distance 4, O, describe the arch O G P.

3. On 3, with the distance 3, P, describe the arch P Q.

4. On 2, with the distance 2, Q, describe the arch Q V.

5. On 1, with the distance 1, V, describe the arch V R.
6. On 4, with the distance 4, R, describe the arch R S.
7. On 3, with the distance 3, S, describe the arch S T.
8. On 2, with the distance 2, T, describe the arch T W.

Lastly, On 1, with the distance 1, W, describe the arch W E; and in the like manner may it be described to any magnitude desired; where any person desires to have this line double, treble, quadruple, &c. they must proceed according to the preceding rules of the foregoing problems, and their desires will be answered.

PROBLEM VII.

To describe a volutus, or scroll, to any magnitude required.

As for example, Describe the voluta, fig. VI. with the parallel distance of its lines equal to the given line X X.

1. Take the length X X, and on A, describe the circle D 4 C 3; and through the center A, draw the right line of direction S P.

2. Divide the diameter of the circle into four parts, as at 1, A, 2; and set off as many of those small divisions on the same line of direction, without the circle (as those at 6, 8, 5, 7, &c.) as are convenient for your purpose.

3. That being done, on the point 2, with the distance 3, describe the semicircle 3 E 7; and on 1, with the same distance, describe the semicircle 4 B 8.

4. On 2, with the distance 2, 8, describe the arch 8 F G.

5. On the point 3, with the distance 3, 7, describe the semicircle 7 H L, and on the same point, the semicircle K N P.

6. On the point 4, and at the distance 4 L, describe the semicircle L M O; and on the same point the semicircle G I K.

7. On the point 6, with the distance 6 O, describe the semicircle O Q T, and on the same center the semicircle P R S, &c. so that it now appears, that the oftner

L

'tis

Fig. VIII.

'tis turn'd round, so many more centers must be added, as those of 5, 7, 8, &c.

This figure has been very much used in parterres, flower knots, &c. but best for an entrance into a cabinet, or private place of repose in the quarter of a wood, wilderness, &c. And besides all the foregoing lines of the six last problems, there is yet another, far superior to any of them, when apply'd to practice in rural works, and is what (as I said before) I call an artinatural line, and is to be described according to the following problem.

PROBLEM VIII.

To describe an artinatural line, in such proportion as traced by hand.

Fig. VIII.

It's to be observed, that there is no set form for this line, it being various according to the discretion of the hand that traces the same; therefore what is to be understood by this problem is, how to find the centers of such arches as will describe the line traced, or very near thereunto. As for example,

Let it be required to find the centers of such arches as will describe the artinatural line B C D F G H K L M, &c.

1. By discretion, divide the several turnings, into such parts as doth appear to be segments of circles.

2. In every such division make three points at pleasure; and by problem XI. sect. I. find the centers thereof, and describe the several segments therein contained, and they will complete the line as required. And as the only use that this line can be applied to, is in pleasant foliary walks of a wood, wildernesses, &c. therefore such breadth as is assign'd them, may be described on the same centers parallel thereunto. See the diagram, wherein one view will give more instruction than many words.

S E C T. VI.

P L A T E IV.

Of the Geometrical Contruncation of the Cube, Parallelepipedon, and the solid Bodies generated thereby.

And in consideration, that the following operations wholly depends upon the division of a right line into extream and mean proportion ; I will, therefore, first lay down

H O W to divide any right line (as the given right line Fig. XV. A B) in extream and mean proportion.

Practice.

1. Make the geometrical square C D L N, with every one of its sides equal to the given line A B.
2. On N, with the radius N D, describe the arch, or quadrant, D I L.
3. Bisect C L, C D, N L and N D, in the points O K G M, and draw the diameter K M and O G.
4. Draw the right line I M, and on M, describe the arch I F, and make B P equal to M F.
5. The distance of B P, is the greater segment, and the point P, doth divide the line A B in extream and mean proportion, as required.

Of the Contruncation of solid Bodies.

1. The solid bodies generated by the several ways of cutting a cube, are the canted cube, the frustum of a cube, the tetraedron and its frustum ; the octaedron, dodecaedron, icosaedron, twelve, and thirty rhombs, of which

the tetraedron, octaedron, dodecaedron, and icosaedron, (as likewise the cube) are called regular bodies, by reason they may be inscribed within a sphere. (See 14th book of Euclid.)

2. A cube (by the 37th definition, sect. I. part. I.) is a solid body containing six faces, each a geometrical square, equal to each other, and every angle 90 degrees. This body is very easily made, provided every angle is an exact right angle, which in practice is very difficult to be perform'd. However, although workmen cannot be exactly mathematically true, yet they come so near to the truth, as not to occasion any sensible difference in the operation.

Cube.

Fig. VII.

3. If every face of a cube be divided, as A B C D, by an inscribed geometrical square, as E F G H, whose angular points divide the sides A B, B D, D C and C A, each into two equal parts; and the triangular parts, as E A F, F B G, G D H, H C E, &c. are cut off, the remaining body is what is called the canted cube, containing 14 faces, of which six are geometrical squares, and eight equilateral triangles.

Canted Cube.

4. If within every face of a cube be inscribed an octagon, whose diameters are equal with those of the face of the cube, as the octagon F G H I K L M E, and the triangular parts G B H, I D K, L C M, E A F, &c. are cut off, the remaining body is what is called the frustum of a cube, containing 14 faces, of which six are octagons, and eight equilateral triangles.

Frustum of a Cube.

Fig. VIII.

5. Suppose O S be 10000, and O P the root of $\frac{2}{3}$ 81649, and O Z the root of $\frac{2}{3}$ 86602, divide Z Y into two equal parts, in the point X, and draw the triangle X S O; also draw the like on its opposite side, equal and opposite thereunto. Make O B equal to $\frac{1}{3}$ of O Z, and draw B V, parallel to O S, intersecting the perpendicular X Q, in the point R, which is the vertex of the tetraedron L M N; draw the right lines V W and V T from the point V to the angles T W, and the like from the point B, to the opposite angles of T and W. If the triangular portions V S T, B O P, G L C, &c. are cut off, the remaining body is a prism; whose side T V W, and its opposite, are each triangles, and the other three V T P B, &c. are parallelograms. Lastly, by the points T R X, and the side of the triangle T X, drawn on the base, as likewise by the points P R X, and the other side of the triangle P X; divide the prism, and those parts being cut off, leaves the

Tetraedron.

Fig. IX.

the triangular body called a tetraedron, containing four faces, and each an equilateral triangle.

6. Divide every face of the tetraedron, as Z A, viz. divide every side into three equal parts, and draw the lines bc , ig and fd ; then will the figure $bcigfd$, be a hexagon, and if the triangular parts bac , ibg , fcd , &c. are cut off, the remaining body is called the frustum of a tetraedron, containing eight faces, of which four are hexagons, and four equilateral triangles.

Fig. IX.

Frustum of a Tetraedron.

7. Suppose a long cube, or parallelopipedon, as SYCF, be as follows, viz. Let QS, or WX, be equal to 100000, and XY, or QP, to the root of $\frac{2}{3}$ as aforesaid, 8.1649, and SX to the root of $\frac{2}{3}$ more by $\frac{1}{3}$ thereof 11.5470, make XT, WV and OP, each equal to 2.8867, one fourth of XS, or ZP, and draw the right line VT, parallel to WX, and the like on its opposite side, or base.

Fig. X.

Bisect QS, in R, and draw the equilateral triangle RVT, and the same in its opposite side, so that the point B, of the opposite triangle, be opposite to the point R. Draw the right lines VZ, VO and QV, and the like on the opposite side, and cut off the triangular parts TVZY downwards, and its opposite OPQS, upwards; then will there remain two equal parallelograms VTSRQ and OZBY. Lastly, cut off OVR and TR above, and OVB and TB by the triangle beneath, and thereby, at six cuts, will be made a solid of eight equal faces, each an equilateral triangle, called an octaedron.

Fig. X.

Octaedron.

8. Divide each side of a cube into two equal parts, as DK by q , HG by g , &c. make Dq, or Hg, &c. the radius equal to 100000, and divide them by extrem and mean proportion. Then will Da, Fe, &c. be equal to 6.1803 the greater segment, and ei, md, &c. to 3.8197 the lesser segment. From the greatest segment of one side to the middle of the other, draw right lines, as from m to E, from o to i, from I to g, from e to d, &c. Lastly, If you cut off each triangular prism, as E Bmr, Iogi, aeqd, &c. at 12 cuts, will be framed a solid, containing 12 equal faces, each a pentagon, called a dodecaedron.

Fig. XI.

Dodecaedron.

9. Divide each side of a cube into two equal parts, as BC, by the right line pbed, &c. intersecting each other, at right angles, as the right lines bd and ac, in the point e, make ep, &c. the radius equal to 100000, and let eb, ec, ed, and ec, be each equal to 6.1803 and through the points abcd, draw the four right lines ab, bc, cd, and

Fig. XII.

M

da,

Icōsaedron.

d a, extending each of them to the exterior lines of the face, *A B*, *B C*, *C E*, and *E A*. Divide every face in the same proportion, and thereby is constituted eight equilateral triangles marked in the diagram 2, 3, 4, 5, 6, 7, 8, &c. By which every angle being cut off, the body will then contain six geometrical squares, and eight hexagons. If you make *a c* the base, the point *f* of the other face shall be the vertex to cut out the triangle *a c f*, and *f b* shall be the base and *l* the vertex to cut out the triangle *f b l*, and *l n*, the base, and *c* the vertex to cut out the triangle *l n c*, and the like of all others, till every one be cut off, and the remaining solid will be a body containing 20 faces, each an equilateral triangle, called an icosaedron.

¶ This body may be cut by the aforesaid lines of the dodecaedron, by drawing the parallel lines upon the cube at the distance of the lesser segment instead of the greater.

Fig. XIII.

10. Suppose a parallelopipedon be as follows, viz the length to the breadth as 1 is to the root of $\frac{1}{2}$, so shall *D C* or *P B* be equal $10.\overline{0000}$ and *B A* or *P G*, to $7.\overline{0710}$ Bisect the lines *G H*, *P B*, and *D C*, in the points *E L H*, as also their opposites, and draw the right lines *H B*, *H P*, *I G*, *I A*, *I D*, *I C*, *E B*, *E P*, and their opposites; draw the diagonals *D G*, and *F P*, and their opposites, meeting the aforesaid lines of every angle, and thereby constitute triangles, such as *D I G*, &c. Lastly cut away the angle *P*, by the triangle *D I G*, and the like of others, and thereby, at eight such operations, will be left a solid body, containing 12 faces, each a rhombus, called the body of 12 rhombs.

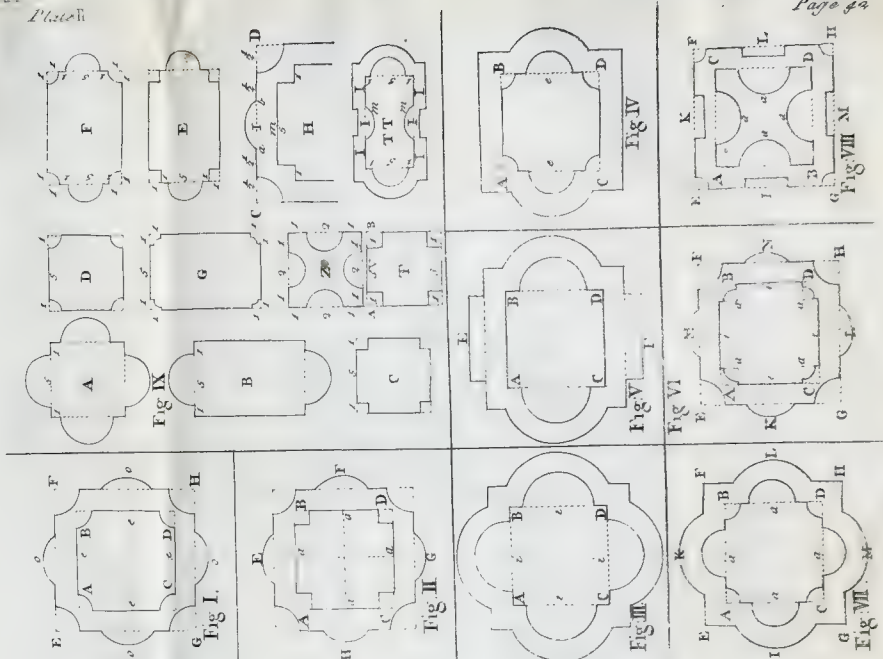
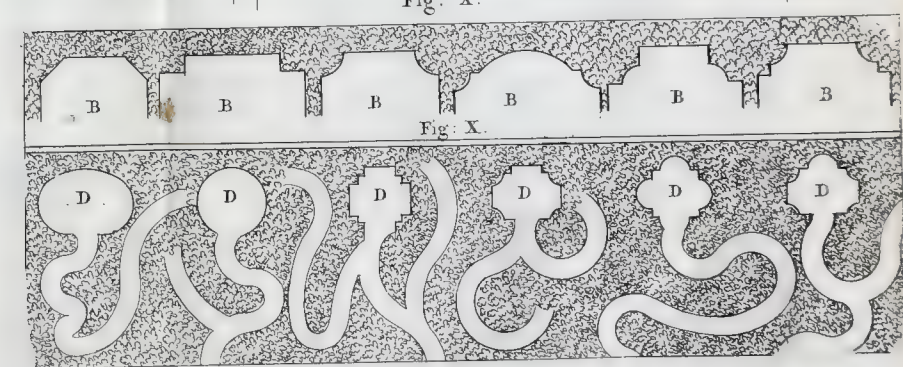
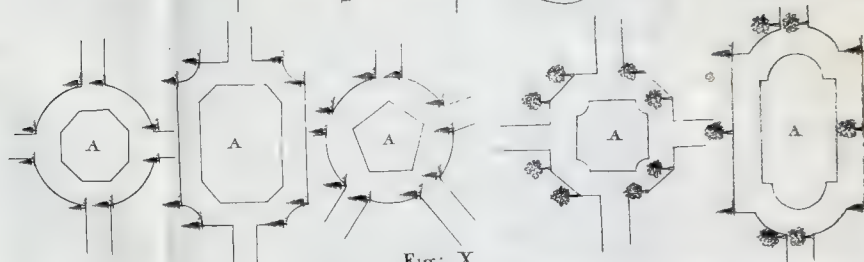
12 Rhombs.

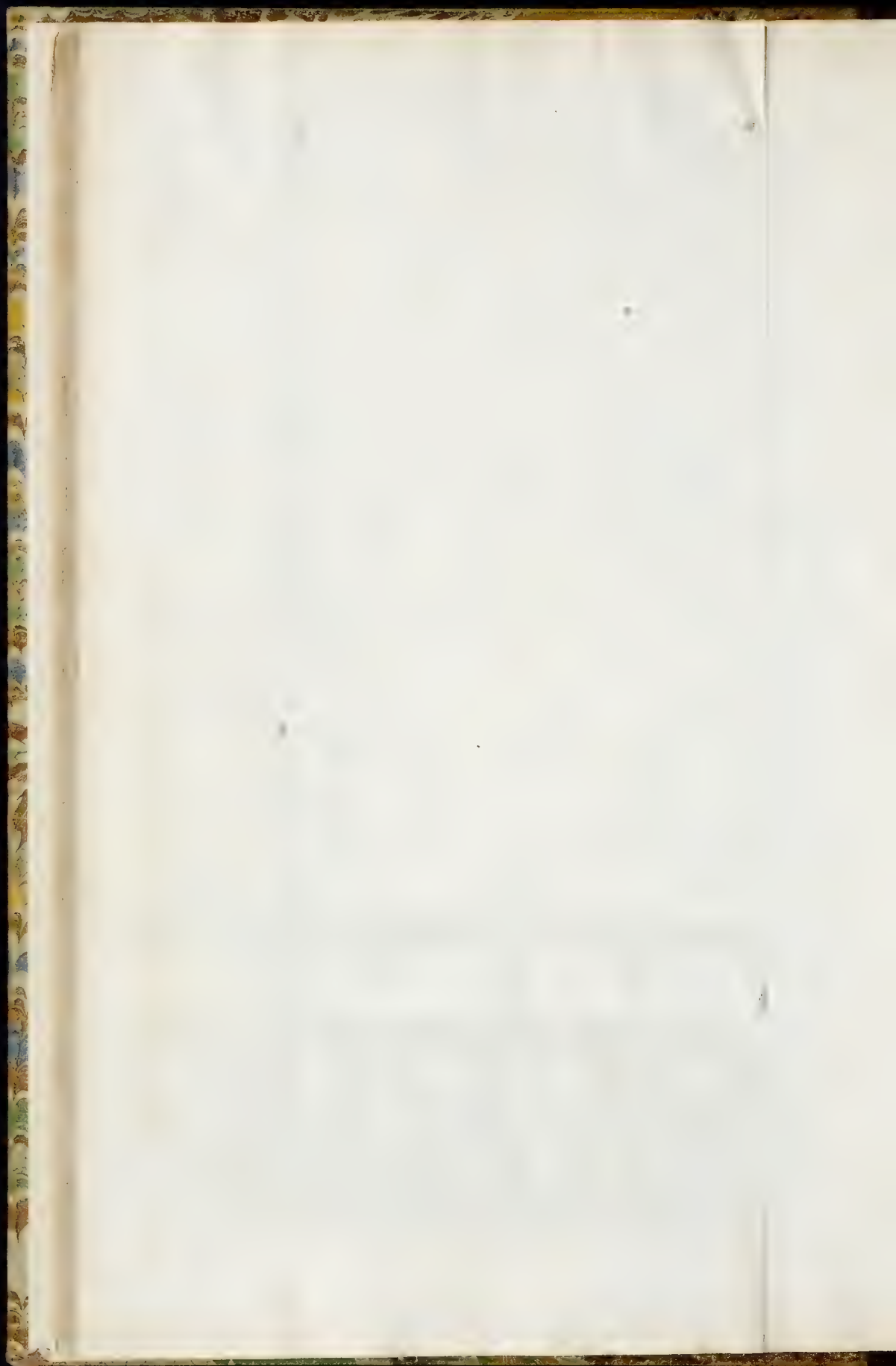
11. Divide every side of a cube by extreme and mean proportion, as the sides *a d*, *d g*, *g k*, and *k a*; in the points *b*, *c*, *e*, *f*, *h*, *i*, *l*, *n*, where each side is equal to $10.\overline{0000}$, and the lesser segments *a b*, *c d*, *d e*, *f g*, *g h*, *i k*, *k l*, and *n a*, each equal to $3.\overline{8100}$.

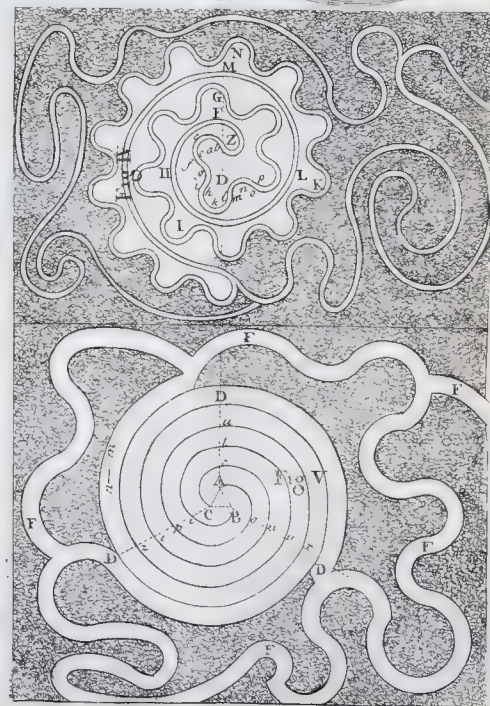
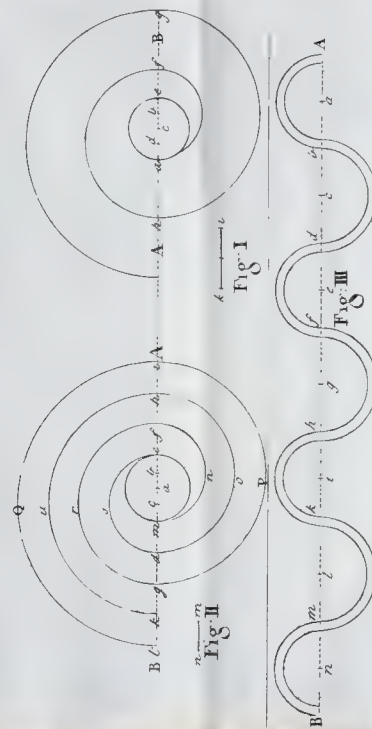
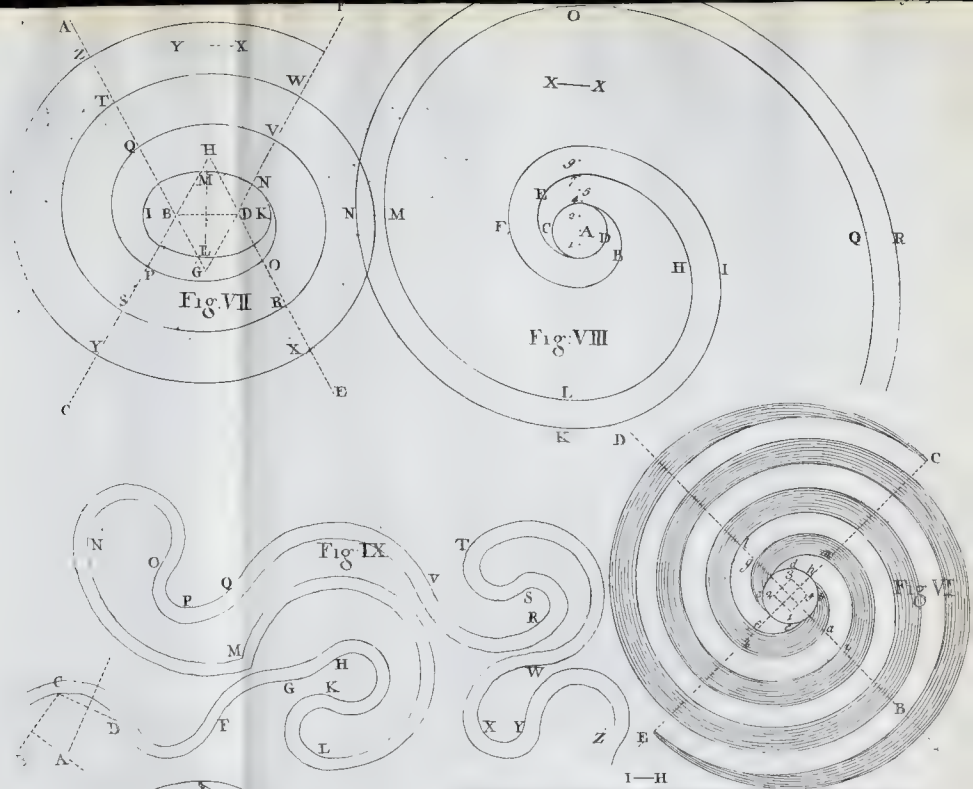
Fig. XIV.

Draw right lines from the terms of the lesser segments, on the one side, to the greater on the other side, as the lines *n c*, *l d*, *e k*, and *f i*, which will be parallel to each other. Also intersect them with the like parallels, as *b e*, *a f*, *n g*, *l h*, and draw the right lines *c g*, *b k*, *h d*, *i a*. Divide every face of the cube in the same manner, and then will the cube be prepared for the operation. About every solid angle of the cube are three triangles, as the triangles 1, 2, and 3, about the angle *a*, and the triangles 4, 5, 6, about the angle *d*, &c. Therefore every angle must be cut three times, always observing to continue each line, as a part is cut away; otherwise 'twill be a confused work; and thereby at 24 such operations, will

30 Rhombs.







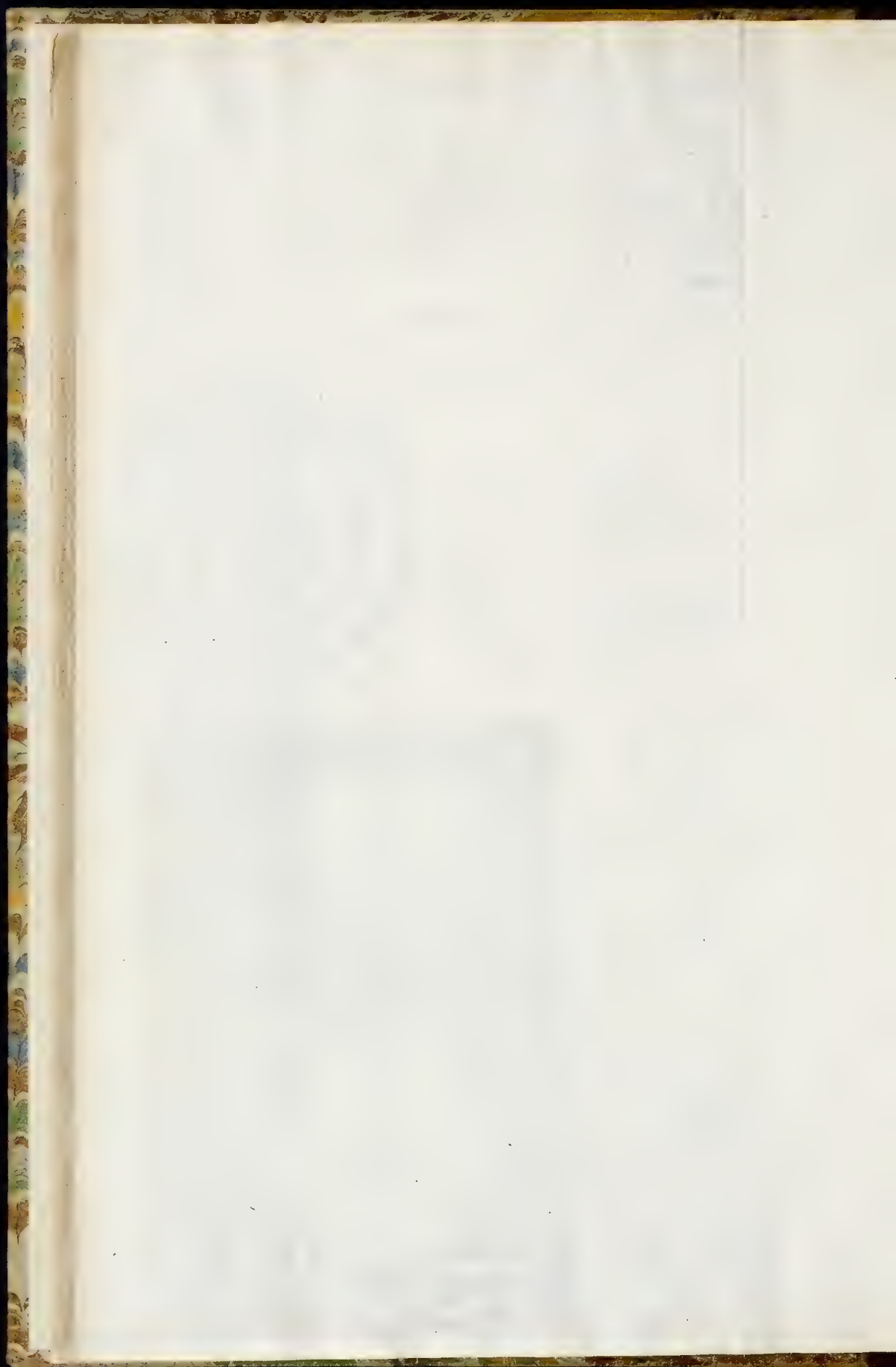


Fig. III.

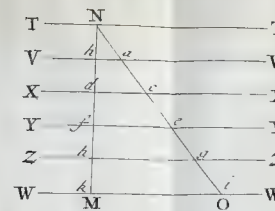
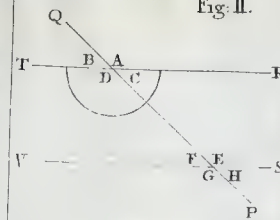


Fig. II.



Page 42 Fig. I.

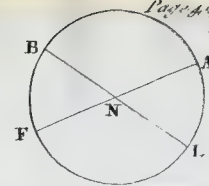


Fig. VI.

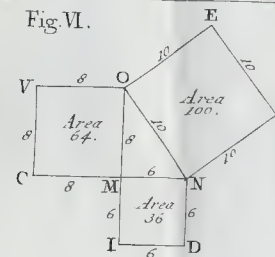


Fig. V.

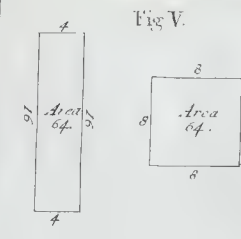


Fig. III.

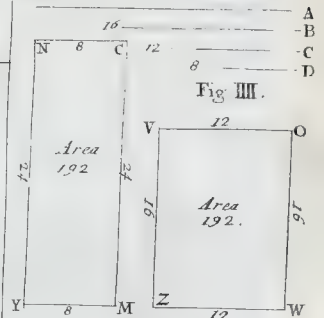


Fig. IX.

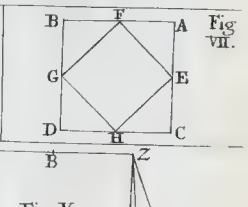
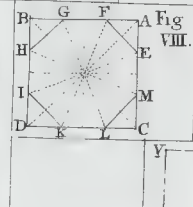
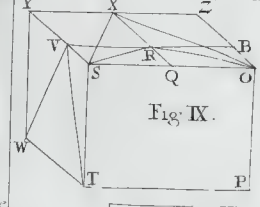
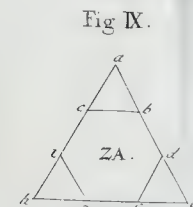
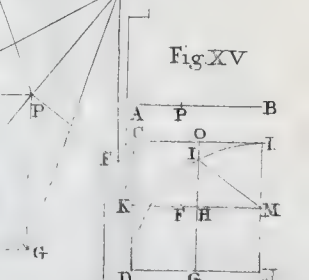
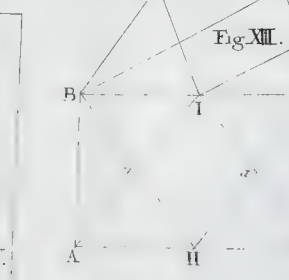
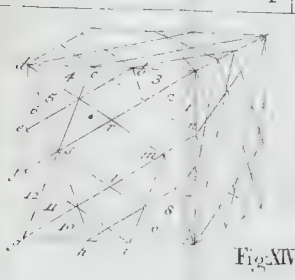
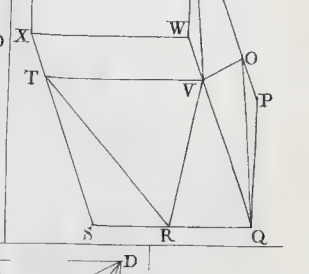
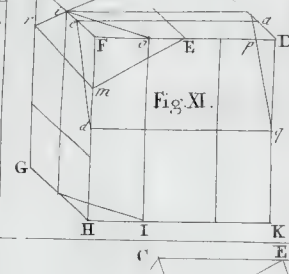
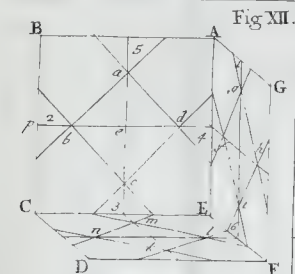
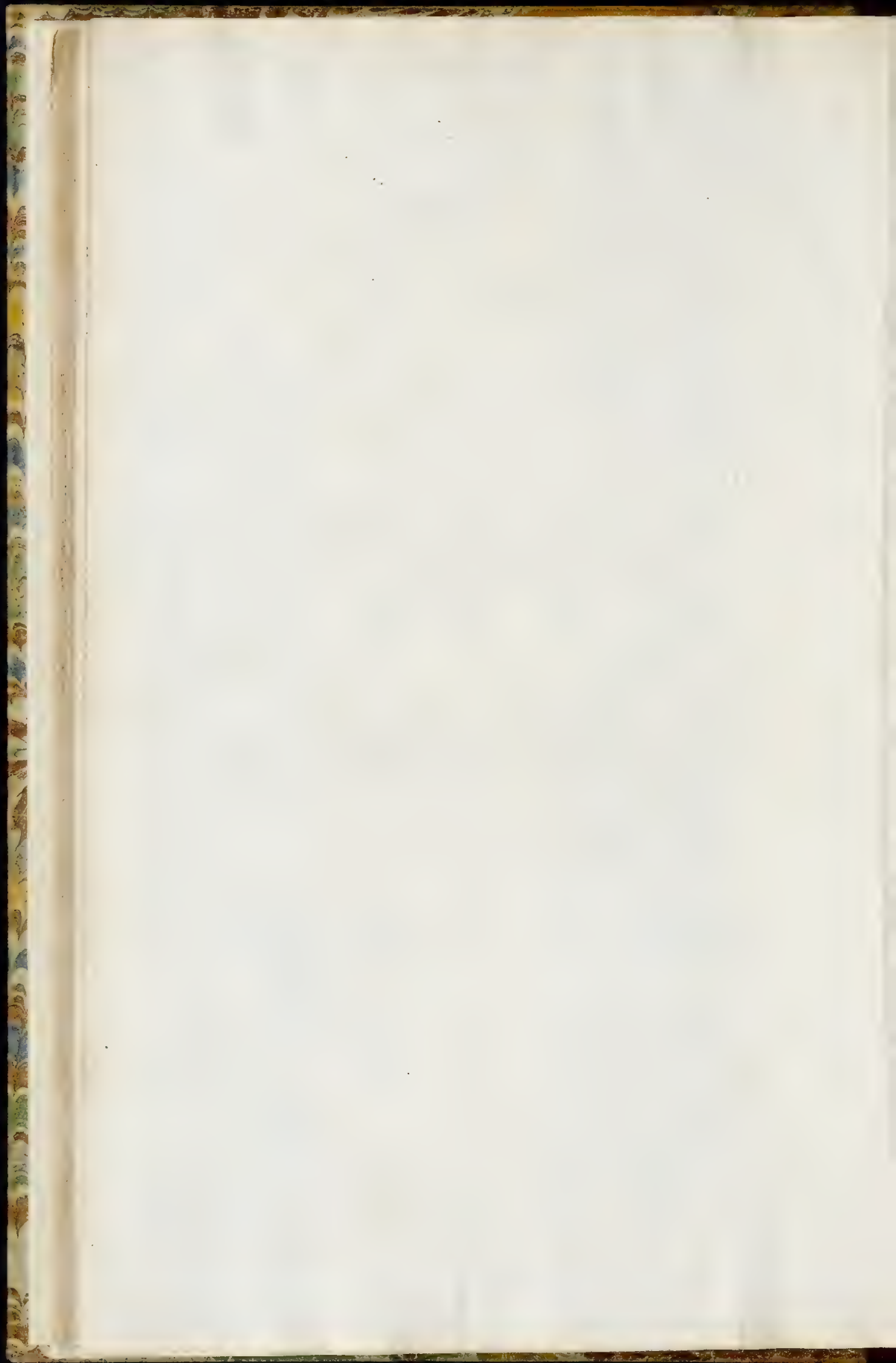


Fig. XII.





appear a solid body, containing 30 faces, each a rhombus, and is called the 30 rhombs.

These bodies are not only very beautiful in divers parts of building, but also in gardening, being placed on a proper pedestal, with a sun-dial delineated upon every face, which may be so contrived as not only to shew the hour of the Day, in all parts of the world, according to the several accounts of time; but also all the most useful parts of astronomy, as the sun's place, declination, amplitude, right ascension, altitude, azimuth, rising, setting, length of day and night, beginning and ending of twilight, æquation of time, &c.





T H E
P R A C T I C E
O F
*Architecure, Gardening, Mensuration, and
Land-Surveying, Geometrically demonstrated.*

P A R T II.

- I. *The Geometrical Construction of the Tuscan, Dorick, Jonick, Corinthian Composita, French and Spanish orders of Architecure, according to any proportions assigned, as also of all kinds of plans and uprights whatsoever.*
- II. *The Geometrical and Trigonometrical Construction of all sorts of Plans, or Draughts of Gardens, Wildernesses, Labyrinths, Groves, &c. and Maps of Cities, Towns, Parishes, Lordships, Estates, Farms, &c.*

S E C T. I.

Of the Geometrical Construction of Plans and Uprights.

P L A T E. V.

*T*O delineate the geometrical plain, or ichnography of a building is to accurately describe a geometrical figure of the several parts thereof in true proportion.

The

The common measure used herein is the english foot, divided into 12 equal parts, called inches, each being equal to the length of 3 barley corns placed in a right line, therefore, an english foot is equal to the length of 36 barley corns. The inches graduated on a foot, or two foot rule, are subdivided in 4, 8, 10, 12, &c. equal parts, according to the pleasure of the architect, &c.

The length, breadth, depth, &c. of any building, (or its parts) are called its dimensions, and the measuring of those dimensions, is called taking the dimensions.

All dimensions, or measures of feet and inches, when taken, are thus written and expressed, *viz.* a dimension, whose length is six feet and ten inches, is written 06 *f.* 10 *i.* and sixty two feet, and five inches, thus 62 *f.* 5 *i.* also if a dimension be fourteen feet and eleven inches in length, by nine feet seven inches in breadth, and two feet ten inches in depth, or thickness, 'tis thus written.

<i>f.</i>	<i>i.</i>	
14	11	L
09	07	B
02	10	D

} &c.

To express one, two, three, &c. feet by a plain scale (or scale of equal parts); every such equal part (as an inch, &c.) doth represent a foot, and two inches, two feet, &c. and if the inches are divided into 12 equal parts, each of those parts will represent an inch. Therefore six feet and ten inches, is represented by six inches and $\frac{10}{12}$, and sixty two feet five inches, by 62 inches 5 parts. And what is here said of the division of an inch into 12 equal parts (for the representation of inches) the same is to be understood in the division of any other length, as $\frac{1}{3}$, $\frac{1}{4}$, $\frac{1}{5}$, $\frac{1}{6}$, &c. of an inch, foot, yard, &c.

When the dimensions of a building are taken in foot measure only (without regard had to inches, which in some works is very common) then any equal division, as is most convenient, may represent one foot, as $\frac{1}{12}$ of an inch, which before represented but one inch, may now represent one foot, and consequently an inch 12 feet; and the like of any other equal part, or division whatsoever. And for the better information hereof, that the young student may have a perfect clear idea, I will here demonstrate the construction of such plain scales, as is most convenient for his purpose.

PROBLEM I.

To make divers scales of equal parts, as shall represent feet and inches.

Fig. I.

1. Draw the right line D B, and at B erect the perpendicular B A, and make B A equal to B D.

2. Divide D B into 12 equal parts, at the points 1 2 3 4, &c. And also A B at the points 1 2 3 4, &c.

3. Draw, or continue B D to such a length as you would have the scale to contain; as to E, and draw A A parallel, and equal in length thereunto.

4. Draw A E, and divide it into 12 equal parts, at the points 1 2 3 4, &c.

5. Draw the lines 1, 1. 2, 2. 3, 3. 4, 4, &c. parallel to A A and E B.

6. From the point A to D, draw the right lines A D, A 1, A 2, A 3, A 4, A 5, A 6, A 7, A 8, A 9, A 10, A 11, and the line A B is the 12 division.

The 12 central lines thus drawn, do divide the ends of the 12 parallels, each into 12 equal parts; therefore each of those lines, so divided, doth represent one foot divided into 12 inches, as Z 1, and if you take the distance Z 1 in your compasses, and set that distance from Z to F, and from F to G, and from G to H, &c. each of those divisions shall be a foot, and equal to Z 1, the foot divided in 12 parts. And to take off with your compasses any number of feet and inches required, proceed as follows,

Let it be required to take off four foot eleven inches.

Practice.

Fig. I.

Set one point of your compasses in the point 4 I, and extend the other on the same line, to the point of intersection of the central line A 11, and the line 1, 1, from which you take the measure, and that length shall truly represent four foot and eleven inches, according to the division of that line. And what is here said in respect to the division of this line, the same is also to be understood of all others. And from hence it appears, that therein there

there is contain'd 12 various scales, and each representing feet and inches, which is what was required to be done. The construction of the scales of foot measure fig. II. are made by the very same rule, only the sides K L and L M, are divided into 10 equal parts each, instead of into 12, as in fig. I. Fig. II.

I shall now proceed to the construction of one other useful scale, which is called a scale, or line of chords, and is of as great use in measuring the angles of a building, as the other in measuring the sides, &c.

PROBLEM II.

To make a line (or scale) of chords, to any assign'd length.

Definitions.

A chord, or subtense, is a right line joining the extremity of an arch; so A C is the chord of the arch A M C.

A line of chords is no other than 90 degrees of the arch of any circle, transferr'd from the limb of a circle to a right line.

Every circle (great or small, see problem III. part I. sect. I.) is divided into 360 equal parts, term'd degrees, Fig. III. and consequently a semicircle into 180, and a quadrant into 90. The semidiameter of a circle, or the side of a quadrant, is always called the radius, and is ever, in all circles, equal to 60 degrees of the same; therefore when the word radius is hereafter mention'd, then sixty degrees is to be understood also.

Construction.

2. Describe the semicircle B M D O, and on O erect the perpendicular O M, which will divide the semicircle into two quadrants.

2. By problem XXX. part I. sect. I. divide the arch M C D into 90 equal parts or degrees.

3. On the point D set one foot of your compasses, and extend the other to 10, and describe the arch 10, 10, then open them to 20, and on the same point D describe the arch 20, 20, and in the same manner the arches 30, Fig. III.
30,

30, 40, 40, 50, 50, 60, 60, 70, 70, 80, 80, and 90, 90, which several arches will intersect the diameter BD, in the points 90, 70, 60, 50, 40, 30, 20, and 10, and divide it into unequal parts. This line, thus divided, is the line of chords, divided to every tenth degree, and by the same rule you may divide it to every degree, and therefore needs no further explication. And as the only use of this line is to measure the quantity of any angle, therefore 'twill not be improper, first to demonstrate the variety of angles.

Demonstration.

Fig. IV.

When two right lines, as EF and FG, join each other, in a right lined position, they then make no angle, but do constitute a right line equal to both their lengths; so the line EF and FG, meeting together in a right line position, at the point F, do constitute the right line FG. But when two right lines meet, and not in a right lined position, as the right lines AD, and HD, (or AD and BD, or HD and DC) such lines, by such meeting, form an angle. The meeting of such lines may happen in three several positions.

1. Two right lines may meet as the right line BD on the line AC, in the point D, making the distance from B to A, equal to BC, viz. the line BD, perpendicular to the line AC, and thereby constitute two equal angles, each containing a quadrant or arch of 90 degrees, and are called by the name of right angles. Therefore whenever a right angle is mention'd, an angle of 90 degrees is to be understood.

2. Two right lines may meet as the right lines AD and HD, and thereby constitute an angle, less than 90, and therefore is called an acute angle.

3. Two right lines may meet, at the right lines HD and DC, and thereby constitute an angle, more than 90 degrees, and therefore is called an obtuse angle, and the sum of all is, that an angle is either acute, right, or obtuse.

An acute angle is that whose measure is less than a quadrant, or arch of 90 degrees.

A right angle is that whose measure is a quadrant, or arch of 90 degrees. And,

An obtuse angle is that whose measure is more than a quadrant, or arch of 90 degrees.

Fig. IV.

The measure of an angle is an arch of a circle, described upon the angular point, intercepted between the two sides,

as

as containeth the angle, (an angle is always expressed by three letters, whereof the middle letter always denotes the angular point, as for example, if you express the angle ZXY , the letter X signifies the angular point, and the like of all other angles, in general).

The complement of an angle, (or arch) is so much of an arch, as the arch that measures the angle wanteth of a quadrant or arch of ninety degrees. So if an angle containeth 60 deg. the complement to an arch of 90 deg. or quadrant is 30 deg. and the like of any other angle.

All angles concurring upon one right line in a center, being taken together, are equal to a semicircle, or 180 degrees. Fig. V.

So the angles of the right lines aaa , &c. meeting at the point C , are (taken together) equal to a semicircle or 180 degrees.

Having thus shewn the construction of plain scales, scales of chords, &c. and the nature of angles, I shall now proceed to apply them to practice, in the delineating of plans in general.

PROBLEM III.

To make a plan equal to a plan given.

Let it be required to make the plan XY , equal to the given plan TV .

1. By problem VII. part I. sect. I. having first drawn the line 1, 2, and made the same equal to AB , make the angle 2, 1, 3, equal to the angle BAC . Fig. VI.

2. Make the line 1, 3, equal to AC , and make the angle 1, 3, 4, equal to the angle ACD .

3. Make 3, 4, equal to CD , and make the angle 3, 4, 5, equal to CDE .

4. Make 4, 5, equal to DE , and make the angle 4, 5, 6, equal to DEF , and by the same rule pass through the whole, and thereby you will complete the plan XY , which will be equal to the given plan TV .

PROBLEM IV.

A second example.

Let it be required to make the plan YZ , equal to the given plan WX .

O

1. Make

1. Make the parallelogram 1, 2, 9, 10, equal to A B L M, and draw the diameters 23, 23, and 21, 22.
2. Make 1, 3, 2, 4, 7, 9, and 8, 10, equal to A G, B H, I L, and K M.
3. Make 1, 19, and 20, 2, equal to A E and F B.
4. Continue the longest diameter infinitely, and make 23, 16, equal to W T, and by problem XI. sect. I. part I. describe the arch 19, 16, 20.
5. Make 21, 5, and 22, 6, equal to O R and O S, and, by the aforefaid problem, describe the arches 3, 5, 7, and 4, 6, 8.
6. Continue the end 9, 10, and make 11, 9, and 10, 12, equal to N L and M O.
7. Make the parallelogram 11, 12, 13, 14, equal to N O P Q, and make 13, 17, and 18, 14, equal to P C and D Q.
8. Continue 23, 23, infinitely towards 15, and make 23, 15, equal to W, V.
9. By problem XI. part I. describe the arch 17, 15, 18, and 'twill complete the plan as required.

Fig. VII.

N. B. If any plan has a thickness, as the walls of a building, &c. that thickness (be what it will) must be drawn parallel to the external figure, in such proportion as the thickness is found.

PROBLEM V.

To measure (or take) the quantity of an angle by the help of a two foot rule, five foot, or ten foot rod only.

Fig. VIII.

Let C A B be the angle of a building, and 'tis required to draw upon paper an angle equal thereunto.

1. From A towards B, measure, or set off, any number of feet (as for instance in this example five foot) and also from A towards C, at the points 5 and 5.
2. Measure the distance between 5 and 5, and note it down on paper.
3. To draw the same upon paper, first draw a line at pleasure, as D E, and from any scale of equal parts take off five parts, representing the five foot set off from A,

the angle aforesaid. With this distance set one foot on D, ^{Fig. VIII.} and with the other describe the arch o, o . Take ten foot in your compasses (the distance between s and s) and set one foot in o , and with the other intersect the arch o, o , in the point P, through which, from D, draw the right line D P N; so shall the right lines D E and D N, form the angle NDE, which shall be equal to the angle CAB, as required. And what is here said concerning the taking off this angle, the same rule is also to be understood of all other angles in general, be they acute, right, or obtuse.

PROBLEM VI.

How to take the plan of a crooked line, or wall, which is not any part of an ellipsis or circle.

Let it be required to describe the plan of the crooked line A B C.

Practice.

1. On a piece of paper describe a crooked line, as near like the crooked line A B C as you can, and draw the straight line A C; this being done, measure two foot (or more according to the nature of the curve) from C in a right line towards A, as from C to 2.

2. Measure from 2 to the crooked line, as to e , and on your paper, or eye-draught, make a mark representing the point 2, and from thence draw a line to the curve, to represent the offset 2 e , and thereon set down the measure of the offset 2 e .

3. At a proper distance from 2, as at 4, take another offset, and signify the same in your eye-draught with the true measure of the same; as also its distance from C, and in the same manner proceed, making as many offsets as the turn of the curve requires, 'till you have taken the whole down. This being done you may describe the same on paper, truly thus: Fig. IX.

1. Draw the line A C, by a scale of equal parts, equal in length to A C.

2. Set from C to 2, the distance measured, and on 2 erect the perpendicular 2 e , and thereon set off the length of that offset, as specify'd in your eye-draught.

3. Set

3. Set the distance C 4, and on 4 erect the perpendicular 4 f, and thereon set off the length of that offset as measured. And in the like manner lay down the distance of every offset from one another, and their proper lengths, and then you have the ends of all your offsets, through which you may exactly trace the crooked line, as required.

Note, That the greater the number of offsets are taken, the more exact the curve may be drawn.

PROBLEM VII.

How to take the plan of any building whatsoever.

The first step to this performance, is to make an eye-draught of the same, *viz.* a rough draught drawn by hand only, expressing every wall, partition, room, door, chimney, window, &c. and the larger these kinds of draughts are made, the better 'tis for you, by reason you have good room to set down every dimension, which in a small draught cannot be done.

Let it be required to make a plan of E F G H, which is supposed to be a real house.

Practice.

1. Make your eye-draught thereof as A B C D, and therein represent every door, window, passage, stair-case, partition, thickness of walls, rooms, &c.

2. With your five foot, or ten foot rod, measure the length and depth withoutside, and note those measures down to each respective side, or length.

3. Measure the thickness of those outside walls, and note them down also.

Fig. X.

4. By problem XXXII. sect. I. part I. examine every angle, whether they be square or not. If they are found to be square, note it down, and if not square, as acute, or obtuse, then measure the quantity of one by problem V. hereof, and thereby, with the length of the four sides given, you may, when you come to draw the plan of the same, by problem XIX. sect. I. part I. delineate the same exactly.

5. Measure the exact breadth of every door and window withoutside, and also the peers of brickwork between them, and set those measures down to each respective part. The outside walls being thus measured, the next proceeding to be made is in the distribution of the parts of the house; therefore walk over the same, and as you walk draw every particular room, with its chimney, doors, &c. as near the truth as may be, as also every stair-case, passage, closet, &c. which being finished, your eye-draught is now fitly prepared to receive every dimension that is to be taken. To which proceed, *first*, as 'tis best to begin in a corner room. Therefore make a beginning at I, where you must measure the exact length of every part thereof, as also the thickness of its party walls, or partitions, and note each measure down severally in its respective place, and then proceed to K, and there perform the same, as also at L, M M, N, O, P, Q, &c. and thereby you'll have taken the just dimension of every part contain'd on that floor. And in the very same manner, may you take the plan of the cellars and other lower offices, or chambers, when required.

Fig. X.

Your eye-draught being thus finished, the next work is to delineate a true draught thereof from those measures taken, which thus perform.

1. By the measures taken, it appears the house is a parallelogram 60 foot in front, and 40 foot in depth; therefore, with your scale of equal parts, describe a parallelogram, whose longest sides are each equal to 60 parts, and the shortest to 40 parts.

2. The thickness of the outside walls are found to be three bricks in thickness, which is equal to two foot and three inches, therefore, at the distance of two foot and three inches, of your scale, draw the interior line, parallel to the exterior, and those two parallel lines do represent the thickness of the outside walls.

Fig. X.

3. By the measures of the eye-draught the distance from the angles to either of the adjacent windows is four foot, as also every window and peer of brickwork between. Therefore, divide the external lines A B, B D, A C and C D, in such proportion, as the eye-draught doth exhibit, as also the internal line likewise, and thereby every window and out doors are truly divided in their proper places.

P

4. Draw

4. Draw the diameters O K and M M, and on each side the diameter O K set off $\frac{1}{2}$ the breadth of the halls O and K, viz. 8 foot 10 inches, and draw on each side the lines V V and V V, and also the thickness of those walls, as they are found to contain.

5. On each side the diameter M M set off two foot the $\frac{1}{2}$ breadth of the entrance, and draw the parallel lines X X and X X, which will divide the parts N L and P I, into four equal parts.

6. Draw the thickness of the lines X X and X X, as they are found to contain.

7. Give to the door of every room, as Z Z Z Z Z, its proper breadth, and from thence set off the side of each room towards the chimney, and draw the front of every chimney, as also set off the jaumes and chimney likewise, according to every respective measure of your eye-draught.

Fig. X.

Lastly, Divide the two stair-cases according to each respective measure, and the plan will be completed, as required.

N. B. That the space contain'd between any two parallel lines, that represents the thickness of a wall, must always be fill'd up with Indian ink, &c. that thereby the same may be understood to be a solid, as likewise the basis of columns, as y y y y and y, &c. and those parts that represent a door, or window, to be left clear without any filling up. See fig. X.

☞ I do advise the young practitioner to consider this problem well, and to practice herein for some time, before he proceeds any further, that he may be perfect, which may be done by a few days practice.

This problem of taking the plans of houses, is one of the most useful in architecture, and the easiest to be acquired; therefore consider the reasons of the same judiciously before you proceed to problem VIII.

PROBLEM VIII.

How to draw the geometrical upright (or front) of any building.

Let it be required to draw a geometrical upright of the house A C B D, which is an elevation raised from the plan E F G H, fig. X.

Fig. XI.

1. Make your eye-draught X, and then repair to the building, and measure the whole front from B to D, which being just 60 feet, write down the same at the bottom of your eye-draught.

2. Measure the whole height from the ground at B to A, which being just 37 feet, write down the same on your eye-draught against the middle of the height.

3. Measure the distance from B to *o*, from *o* to *p*, from *p* to *q*, from *q* to *u*, from *u* to *r*, from *r* to *s*, from *s* to *u*, from *u* to *w*, from *w* to *x*, from *x* to *y*, from *y* to *z*, from *z* to *z a*, from *z a* to *z b*, and from *z b* to D; and write down the several measures in each respective place.

4. Measure the distance from G to *h*, from *h* to *i*, from *i* to *k*, from *k* to *l*, from *l* to *m*, from *m* to *n*, and from *n* to A, and write down the several dimensions, or measures, in their respective places, as may be seen in the eye-draught.

The measures, or dimensions, being thus taken, and noted in your eye-draught, proceed to the delineation thereof as follows.

1. Make the parallelogram A C B D, in such proportion that A C and B D, do contain 60 feet of any plain scale, and the sides A B and C D 37 feet, as noted in the eye-draught.

2. On the lines B D and A C, set off the several measures *h*, *o*, *p*, *q*, *u*, *r*, *s*, *t*, *u*, *w*, *x*, *y*, *z*, *z a* and *z b*.

3. Draw the lines *o o*, *p p*, *q q*, *u u*, *r r*, *s s*, *t t*, *u u*, *w w*, *x x*, *y y*, *z z*, *z a z a* and *z b z b*.

4. On the lines B A and D C, set off the several measures 3, 4, 8, 4, 8, 4, 6, at the points *h*, *i*, *k*, *l*, *m*, *n*, E, and draw the lines *h h*, *i i*, *k k*, *l l*, *m m* and *n n*, which will intersect the former, and truly form every window, door, &c. contained therein, and thereby complete the geometrical upright as required.

PROBLEM IX.

P L A T E VI.

To delineate the geometrical upright of any of the five orders of architecture (contained in any structure) according to any proportion assigned.

For Example,

Let it be required to delineate the geometrical upright of the attick base, with the dorick capital, architrave, freize and cornish.

The measuring rod, with which the severall parts of a column and its entablature are measured, is the diameter of the column divided into 60 equal parts, called minutes. Every architect divides the members, or parts of his orders, in such proportion as he thinks most agreeable, as may be seen in the last folding pages hereof, wherein are exhibited, not only the geometrical profiles and sections of the most noble antient orders of the *Romans*, but also of *Vitruvius*, *Palladio*, *Scamozzi*, *Serlio*, *Vignola*, *D. Barbaro*, *Cataneo*, *L. B. Alberti*, *Viola*, *Bullant*, *P. De Lorme*, *Perrault*, *Le Clerc*, *A. Bosse* and *Michael Angelo*; which I thought fit to subjoin to this work, in such a manner, as for the young student to behold, at one view, the great variety contained among them, as well as to make choice of such as might best suit his purpose.

The division of each member is a line, and the distance between any two of those lines is called the height of the member, as the distance between the right lines A A and B 40, viz. the line A B, or A 40.

The projecture of every member is that length contained between the central line of the column and the termination thereof: the entablature of any order is the architrave, freize, and cornish taken together.

Operation.

Fig. XVI.

1. Let XX be equal to the diameter of a given column, divided into 60 equal parts or minutes, by the help of which we'll describe the attick base, as required.
And

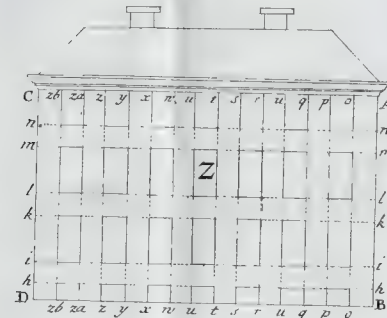
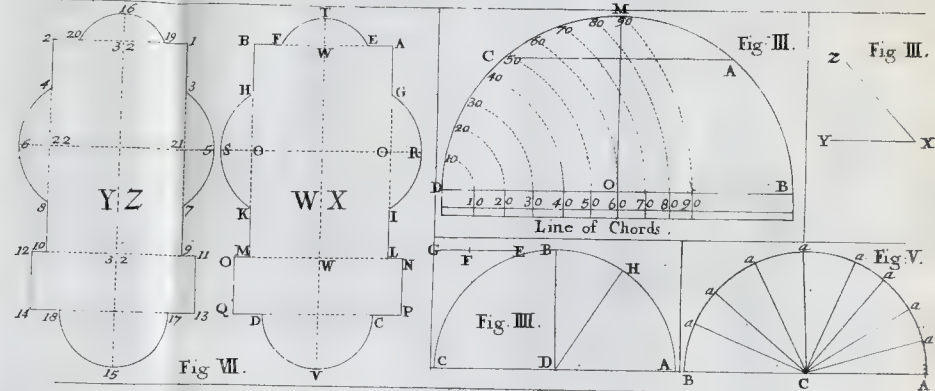
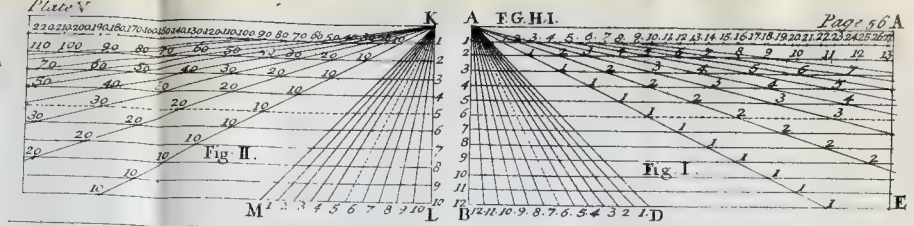


Fig. XI.

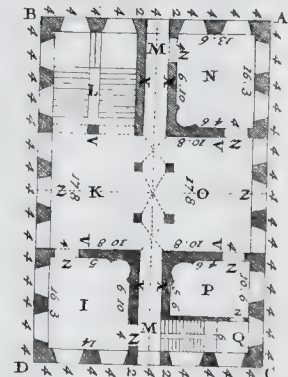
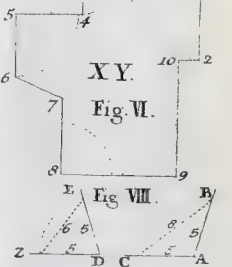
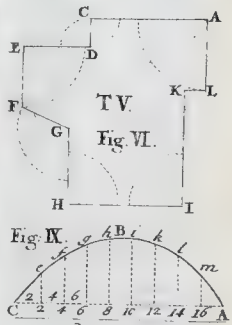
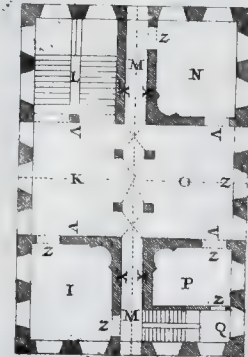
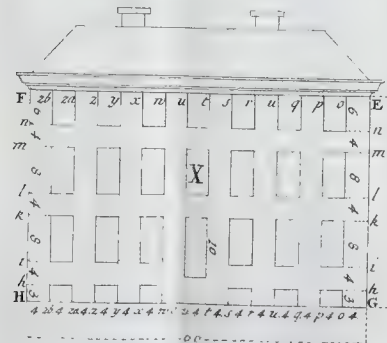
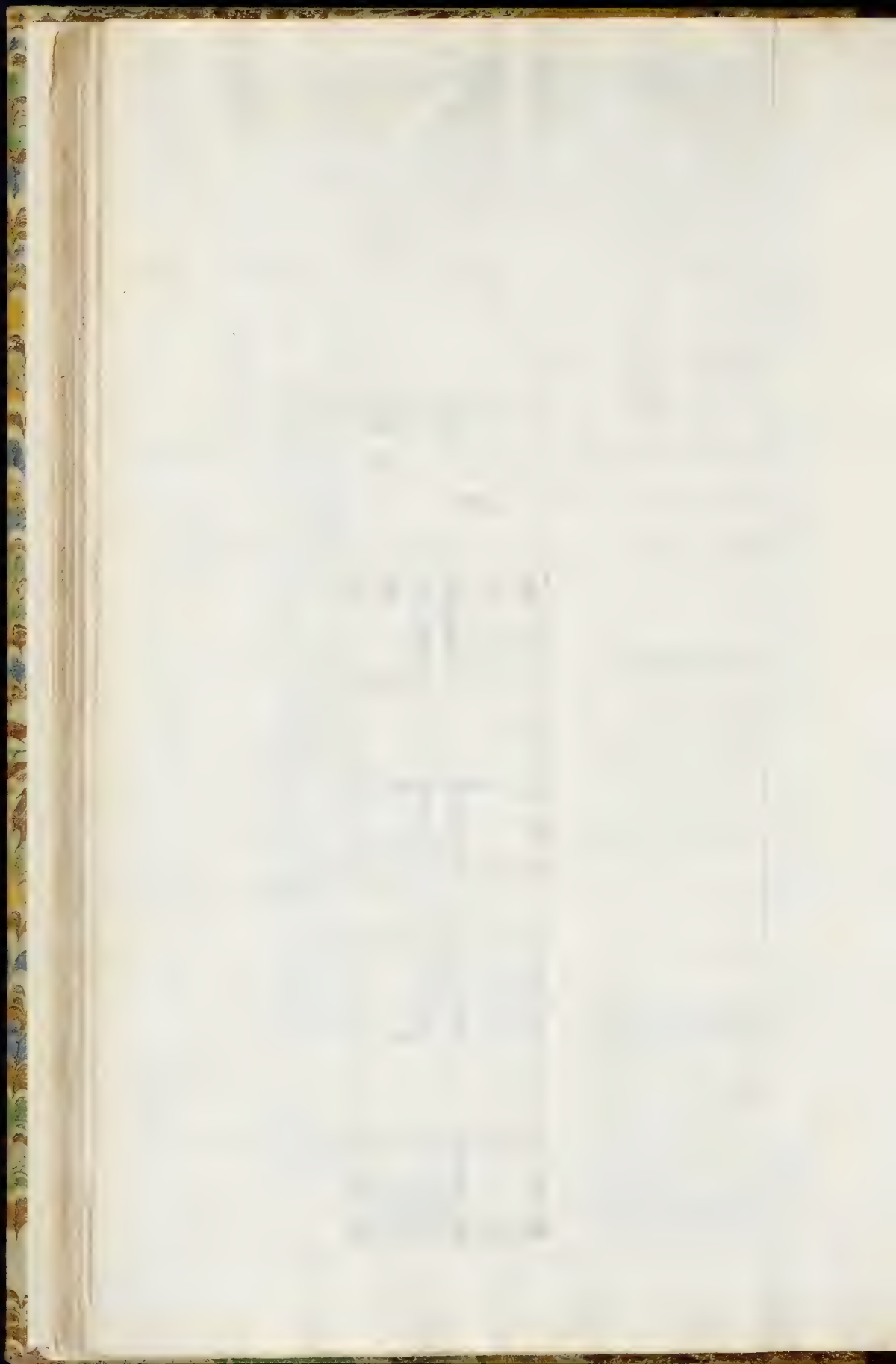


Fig. X.





And as 'tis usual for all architects to prefix to every member its exact height and projecture as in the several figures XVI, XVII and XVIII, therefore draw the right line A B, and make it equal to 40 min. (as there written).

2. On A, erect the perpendicular A D, and let it represent the central line of the column continued through the base; also erect the perpendicular A 40, and continue it infinitely.

3. Because the height of A B and A 40 is 10 min. therefore set off 10 min. from A to B, and from A to 40, and draw the line B 40.

4. The height of the next member B c, is 7 min. $\frac{1}{2}$; therefore set off 7 min. $\frac{1}{2}$ from B to c, and draw c K parallel to B 40.

5. The next member C E is 1 min. $\frac{1}{4}$ in height; therefore set off from c to E one min. $\frac{1}{4}$, and draw the line E L infinitely, and parallel to C K.

6. Because the lines C K and E L, are each 36 min. $\frac{1}{3}$ in length; therefore set off 36 min. $\frac{1}{3}$ from C to K, and from E to L, and draw the line L K.

7. Continue L K to M, and divide K M into two equal parts at N, and thereon describe the arch M P K.

8. The next member E F, is 4 min. $\frac{1}{2}$ in height; therefore set off 4 min. $\frac{1}{2}$ from E to F, and draw the line F n, infinitely.

9. The next member F G is 1 min. $\frac{1}{4}$ high; therefore set off 1 min. $\frac{1}{4}$, and draw the line G o, infinitely, and parallel to all the former.

10. Because the lines F n, and G o, are each 35 min. in length; therefore set off 35 min. from F to n, and from G to o, and draw the line n o.

11. Draw the line n L, and divide it into two equal parts in m, and thereon, with the distance m n, describe the arch n Q L.

12. The next member G H is five min. $\frac{1}{2}$ high; therefore set up 5 min. $\frac{1}{2}$ from G to H, and draw the line H q parallel to G o, and extend it infinitely.

13. The next and last member is one min. $\frac{1}{4}$ in height, therefore set up one min. $\frac{1}{4}$ from H to I, and draw the line I r parallel to the former, and extend it infinitely also.

14. Because the lines H q and I r, are each equal to 33 min. $\frac{1}{2}$; therefore make H q and I r, each equal to 33 min. $\frac{1}{2}$, and draw the line q r.

Fig. XVI.

15. Draw the line q o, and divide it into two equal parts at P, and thereon, with the distance P o, describe the arch o, R, q.

Q

16. Make

16. Make HS equal to 30 min. and on the point S erect the perpendicular St , and make St equal to twice Sq .

17. Draw the right line tr , and on r , with the distance rt , describe the arch tu , and with the same opening on t , the arch ru , intersecting the former in u .

18. On the point u , describe the curve rt , and 'twill complete one half of the attick base and base of the shaft, as required.

*Dorick
Capital.*

2. Let it be required to delineate the getmetrical upright of the dorick capital, fig. XVII.

1. Draw the right line Aa , infinitely, and at A erect the perpendicular AI , for the central line of the capital.

2. At 1 min. $\frac{1}{2}$ distance from Aa , draw the line Bb parallel to Aa , and make Aa and Bb each equal to 28 min. and draw the line ab .

3. At 3 min. $\frac{1}{2}$ distance from Bb , draw the line Cd infinitely, and parallel to Bb .

4. Continue ab to e , and divide be into two equal parts in the point c , and thereon, with the distance cb , describe the semicircle $b30, e$.

5. Set up 9 min. from C to D , and draw the line Df , infinitely.

6. Take 26 min. in your compasses, and set that distance from C to d , and from D to f , and draw the line df .

7. Set up 3 min. $\frac{1}{3}$ from D to E , and draw EL infinitely.

8. Divide ED into three equal parts at the points aa , and draw the line ag and ab , infinitely.

9. Set 30 min. from E to k , and continue df to L , and divide Lk into three equal parts at the points m and n , from which draw lines parallel to fL , and they shall terminate the lines fg bz .

10. Set up 6 min. and $\frac{1}{2}$ from E to F , and draw the line Fn infinitely, and parallel to the line EL .

11. Make Fn equal to 36 min. and draw the line Kn , which divide into 5 equal parts, and on the points K and n , with an opening of 4 of those divisions, describe the arches 22 and 44, intersecting each other in the point m , whereon, with the radius mK , describe the arch Kn .

12. Set up 6 min. $\frac{3}{4}$ from F to G , and draw the line Go , infinitely, and parallel to the line Fn , and at n erect the perpendicular no , and make Go equal to 37 min.

13. Set

13. Set up 2 min. $\frac{2}{5}$ from G to H, and draw the line H s infinitely, and parallel to G o, and make H s equal to 39 min. as also the line I t, at the parallel distance of 1 min. $\frac{3}{4}$.

14. Fig. Z represents the face of the member H s o G, Fig. XVII. which describe as follows, viz. draw the line o S, and bisect it in R, and divide each half into 7 equal parts, and with the distance of 6 of those parts, on the point o, describe the arch 7 7; also with the same distance on R, describe the arch 6 6, intersecting the former in the point 8, and also describe the arch 5 5. This being done with the same opening on the point S, describe the arch 3 3, intersecting the last in the point 9.

15. The points 8 and 9 are the centers of the arches O R and R S, which compose the face of the member, as required.

16. Fig. N represents the fillet B b a A (under the astragal C d e b B) with a section of the shaft, which describe as follows, viz. bisect n A in i, and make n m equal to three times n i, and draw the line A m, and on m, with the distance m A, describe the arch A S, and on A the arch m t, intersecting the former in r, which is the center of the arch or hollow A m, as will complete the capital with the astragal as required.

3. Let it be required to delineate the geometrical up- Dorick, Ar-
right of the dorick, architrave, freize and cornice, fig. chitrave,
XVIII. Freize and
Cornice.

Practice.

1. Draw the line A a, at pleasure, and at a erect the perpendicular a, o, which is to represent a continuation of the central line, from which every measure of projecture, and on which every measure of height is to be accounted.

2. At the parallel distance of 11 min. draw B c infinitely, and make a A and B b, each equal to 26 min. and draw the line A b.

3. At the parallel distance of 14 min. $\frac{1}{2}$, draw c d infinitely, and make B c and C d, each equal to 27 min. and draw the line c d.

4. At the parallel distance of 4 min. $\frac{1}{2}$ draw D g f' Fig. XVIII. infinitely, and make C e and D f, each equal to 30 min. and draw the line e f.

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5. At the parallel distance of 45 min. draw the line $E i$ infinitely, and make $D g$ and $E h$, each equal to 26 min. and draw the line $g h$.

6. At the parallel distance of 5 min. draw $F k l$ infinitely, and make $E i$ and $F k$, each equal to 27 min. and draw the line $i k$, also make $F l$ equal to 30 min. $\frac{1}{2}$.

7. At the parallel distance of 5 min. draw $G n$ infinitely, as also $H o$, and make $G n$, and $H o$, each equal to 35 min. $\frac{1}{2}$.

8. Draw the line $l n$, and divide it into 4 equal parts, and describe the triangle $n m l$, making the sides $n m$ and $m l$, each equal to three parts of $l n$, and the point m is the center of the arch $n, 2, l$.

9. At the parallel distance of 6 min. draw $I P q r$ infinitely, and make $I q$ equal to 39 min. and $\frac{1}{2}$, and make $I r$ equal to 64 min. $\frac{1}{2}$.

10. Draw the line $q o$, and with the distance $o q$ on o , describe the arch $q P$, and on q the arch $o P$, intersecting each other in the point P , which is the center of the arch $q, 7, o$.

11. At the parallel distance of 8 min. draw $K S$ infinitely, and make $K S$ equal to $I r$, and draw $r S$; also make $S t$ equal to 1 min.

12. At the parallel distance of 3 min. $\frac{1}{4}$, draw $L x y$ infinitely, as also $M P$, at the parallel distance of $\frac{3}{4}$ min. and make $L x$ and $M P$, each equal to 68 min. and draw the line $x P$.

13. Draw the line $t y$, and divide it into two equal parts in w , and on t , with the distance $t w$, describe the arch $w u$, and with the same distance on w describe the arch $t u$, intersecting the former in u which is the center of the arch $t w$, and in the same manner on x , describe the arch $w y$.

Fig. XVIII.

14. At the parallel distance of 6 min. $\frac{3}{4}$, draw $N S$ infinitely, as also $O T$, at the parallel distance of 2 min. $\frac{1}{4}$, and make $N S$ and $O T$, each equal to 76 min. and draw the line $S T$.

15. Draw the line $P S$, and divide it into two equal parts in V , and with the distance $P V$ on P describe the arch $V Q$, and with the same distance on V describe the arch $P Q$, intersecting the former in Q , whereon, with the same distance, describe the arch $P V$, and in the same manner on R , the arch $V S$ also, which will complete the profile, or geometrical elevation of the architrave, freize and cornice, as required.

PROBLEM X.

To delineate the triglyphes of the dorick order.

This ornament is seldom used in any order besides the dorick, and is always placed in the freize exactly over the column. The height of this ornament is always equal to the height of the freize wherein 'tis placed, (the capital excepted) and the breadth to half the diameter of the column at the base. In every triglyphe are 7 parts, viz. two entire glyphs or channels (as $\approx m$) meeting in an angle, two femi-glyphes, as $\approx i$, and three interstices or spaces, as $\approx l$, &c. To delineate this ornament you must,

Fig. XVIII.

1. Take 15 min. and place from D to Z, and from E to b , and draw bZ .

2. Divide DZ and Eb , each into 6 equal parts, and draw the lines ab , ab , &c.

3. Set 2 min. from b to x , and from E to z , and draw the line zx .

4. On x , with the distance xo , describe the quadrant on , and with the same opening on m the semicircle on .

Hence it appears, that the triglyphe must be divided into 12 equal parts, of which two must be given to each entire channel, as well as to the spaces between, and one to each femi-channel, at the extreame.

5. Continue the lines bZ , ab , &c. through the lift of the architrave towards ooo , &c. and draw the line qq parallel to ce , and pp .

6. Make the parallel distance of pp , equal to 1 min $\frac{1}{2}$, and qq to 4 min.

Lastly, if right lines be drawn from the points of intersection rr , &c. towards the points ccc , &c. (which are in the midst of the lift) till they meet the line pp , they will truly form the guttæ, or drops, and complete the whole, as required.

These guttæ, or drops, are made either in shape of the frustum of a cone, or pyramis, and oftentimes exact cones or pyraments.

When triglyphs are placed throughout an entablature, the empty spaces between must be exactly square (and are called metops). From whence it happens, that in many structures the triglyphes are left out, on account they can-

Of the Geometrical Construction of

not be so distributed, as to make the empty spaces, or metops, exactly square. These metops are oftentimes enriched with oxes skulls, fruit, flowers, &c. according to the nature of the building wherein they are introduced.

PROBLEM XI.

To describe the upright and inverted cima, or cymaise, vulgarly called ogee.

I. Of the upright cima. Fig. A B.

P L A T E VII.

Practice.

1. Draw the right line $a m$, and bisect it in n .
2. On m , with the distance $m n$, describe the arch $n r$, and also on n the arches $m r$ and $n o$.
3. With the same opening on a , describe the arch $n o$.
Lastly, The points o and r , are centers whereon you may describe the arches $m t n$ and $n i a$, which will complete the upright cima, as required.

II. Of the inverted cima. Fig. A D.

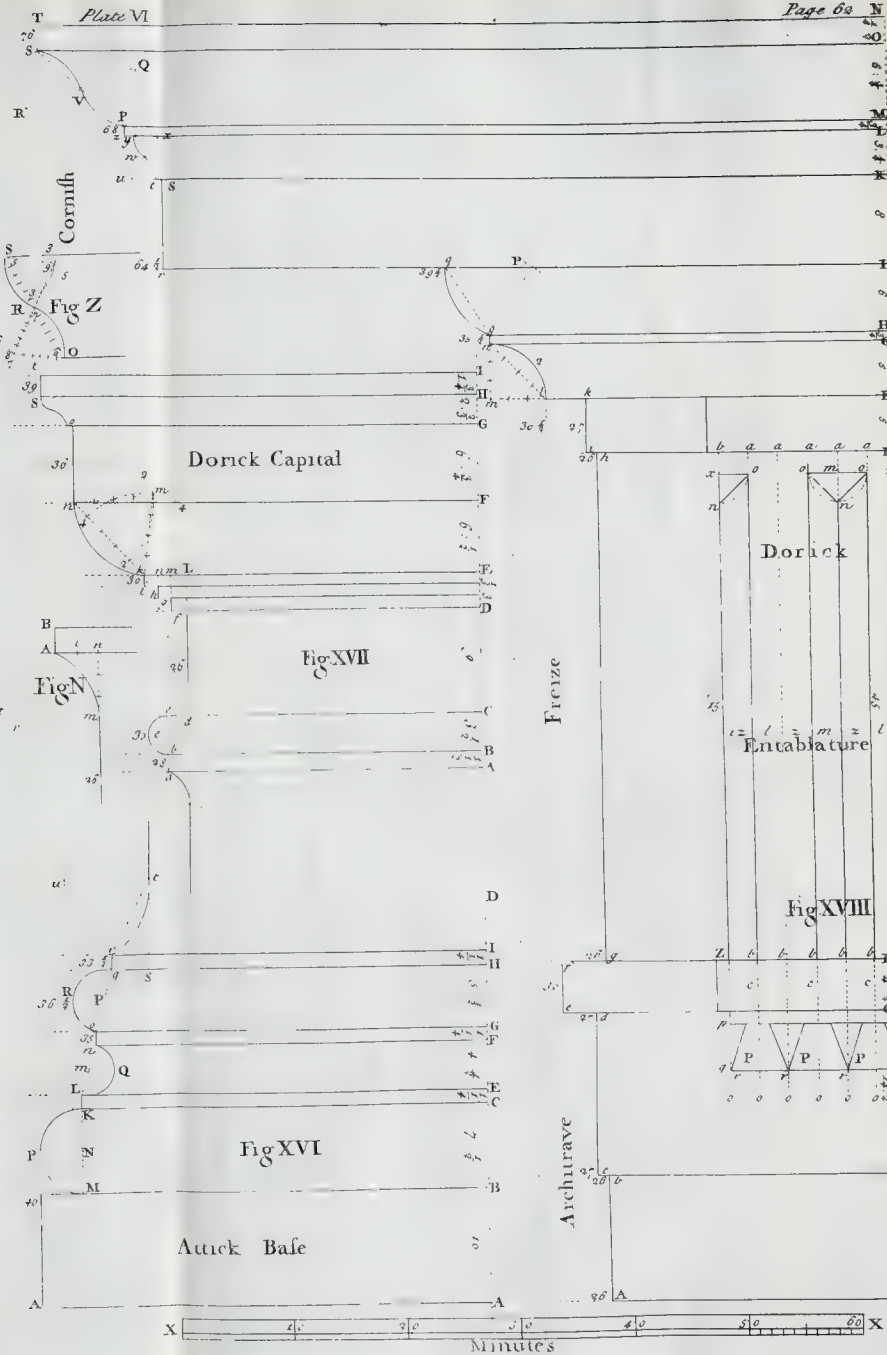
P L A T E VII.

Practice.

1. Divide the projecture given to the cima, as $a b$, into 6 equal parts.
2. Make $m l$ and $g i$, each equal to $\frac{1}{6}$ of $a b$, and draw the line $i m$.
3. Bisect $i m$ in k , and then describe the cima, as in the preceding, and the inverted cima will be completed, as required.

PROBLEM XII.

To delineate the geometrical upright of any pillafter, or column, with its entablature.





I. Of a pilaster.

PLATE VII.

Practice.

1. Draw the line I H for the central line. Fig. I.
2. By the first of problem IX. hereof, delineate the base G.
3. Make K L equal to the assigned height of the pilaster, *viz.* 7 diameters, &c. and through the point L draw B C parallel to E F, and make K F, K E, L C, L B, each equal to the semidiameter of the pilaster, *viz.* 30 min.
4. Draw the right lines B E and C F, and then will the body of the pilaster be completed.
5. By the second of problem IX. hereof, delineate the capital A; and by the third, the architrave, freize and cornish M D N, and then will the whole be completed, as required.

II. Of a column.

PLATE VII.

Practice.

1. Draw the central line A Q. Fig. II.
2. By the first of problem IX. hereof, delineate the base B.
3. Make C I equal to the assigned height of the shaft of the column, *viz.* 7 diameters, &c. and through the point I draw the right line L I K at right angles to the central line A Q.
4. Divide C I into 3 equal parts, and set up one from C to F, and through the point F draw the right line G F H.
5. Make C D, C E, F H and F G, each equal to the semidiameter of the column at the base, *viz.* 30 min. and draw the right lines D H, and E G, parallel to C F.
6. Make I K and I L, each equal to the semidiameter at the capital or head of the shaft, *viz.* 26 min. &c.

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7. On F describe the semicircle $G a a H$, and make the chord line $a a$, equal to $L K$ and parallel to $G H$, and draw the right lines $L a$ and $K a$.

8. Divide the arches $a H$ and $a G$, into any number of equal parts (the more the better) suppose 4, as in the diagram at the points $n m o G$, &c. and draw the lines $n n$, $m m$, and o, o .

9. Divide $F I$ into the same number of equal parts, as $a G$ or $a H$, which in this example is 4, at the points 1, 2, 3, 4, and through the points 1, 2 and 3, draw the right lines $W 1 X$, $T 2 V$ and $R 3 S$, at right angles to the central line $A Q$.

10. Upon the points n and n , erect the perpendiculars $n R$, $n S$, or at the distance of 1 n , draw the lines $n R$ and $n S$ parallel to $F I$, and they will intersect the line $R 3 S$ in the points R and S .

11. At the distance of 2 m , draw the parallels $m T$ and $m V$, and they will intersect the line $T 2 V$ in the points $T V$.

12. At the distance of 3 o , draw the parallels $o W$, and $o X$, and they will intersect the line $W 1 X$ in the points $W X$.

Lastly, lines being drawn from G to L , and from H to K , though the several points of intersection $W T R$, and $S V X$, shall truly form the diminishing (or upper) part of the shaft, as required.

To which being added the capital and entablature, as before taught, the whole will be completed, as required.

N B. That in consideration, as the upper part of the shaft of every column is so much lesser than the upper part of a pilaster, by so much as the diminution of the column is, as generally in the tuscan $\frac{1}{4}$, the dorick $\frac{1}{5}$, the ionick $\frac{1}{6}$, the corinthian $\frac{1}{7}$, and the composita $\frac{1}{8}$, of their diameters at the base, therefore when you are to delineate any pilaster, &c. with its entablature, from any of the geometrical elevations, at the end hereof, you must add to the projecture of every member, half the diminution of the column, and thereby every member will have its true projecture.

PROBLEM. XIII

To delineate the geometrical upright of any wreath'd, waved or twisted columns.

These kind of columns may be described divers ways, but none better than the following.

PLATE VII.

Practice.

1. By the preceeding problem, delineate the corinthian Fig. III. shaft B O D N, and make B A equal to B D.

2. Draw the right line A D, and on the point A with any radius, describe an arch as C Z, which divide into 12 equal parts at the points 1, 2, 3, 4, &c.

3. Lay a ruler from A to the several points 1, 2, 3, 4, 5, &c. and draw right lines to the side of the column D B, as to the points *n, n, n, &c.*

4. From the several points *n, n, n, &c.* draw the right lines *n m, n m, n m, &c.* parallel to the base D N.

5. On N, with the distance N *m*, describe the arch *m i*, and with the same opening on *m*, describe the arch N *i*, intersecting the former in the point *i*, which is the center of the arch N *m*.

6. Perform the same operation at the several divisions, and thereby you will complete the shaft as required.

PLATE VII.

Shewing how to perform the aforesaid operation a different way from the foregoing. Fig. IV.

Practice.

1. By the preceeding problem, delineate the ionick shaft E R P Q, and make P E equal to one third of F P, and draw the right line F E.

2. With the distance E F, on E describe the arch F V, and on F the arch E V, and also on V the arch E 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, F.

S

3. Di-

Of the Geometrical Construction of

3. Divide the arch E I, 2, 3, &c. F, into 12 equal parts, at the points 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, and from them draw right lines parallel to the base P Q, 'till they intersect the column in the points $n, n, n,$ &c. and $o, o, o,$ &c.

4. Divide each of the divisions $n, n,$ &c. and $o, o, o,$ &c. as Q $o,$ or P $n,$ into 4 equal parts, and with the distance of 3 of those parts, describe the several arches therein on the points P, $n, n, n,$ &c. and Q, $p, o, o,$ &c. intersecting each other in $r, r, r,$ &c. which points of intersection are the centers of the several arches that compose the column, and being described will complete the shaft, as required.

PLATE VII.

Shew the like operation in small columns.

Practice.

Fig. V.

1. By the preceeding problem delineate the dorick shaft S T G I, and make I K and G H, each equal to G I, and draw H K, and the diagonals K G and H I, intersecting each other in n , whereon describe the arch K I.

2. Make the triangle G m H, equal to the triangle I n K, and on m describe the arch H G.

3. Make K M and H L equal to H K, and draw the line L M and the diagonals M H and L K, intersecting each other in u , the center of the arch H L.

4. Make the triangle K w M equal to K u M, and on w describe the arch K M, and so on with all the others, and thereby the whole will be completed as required.

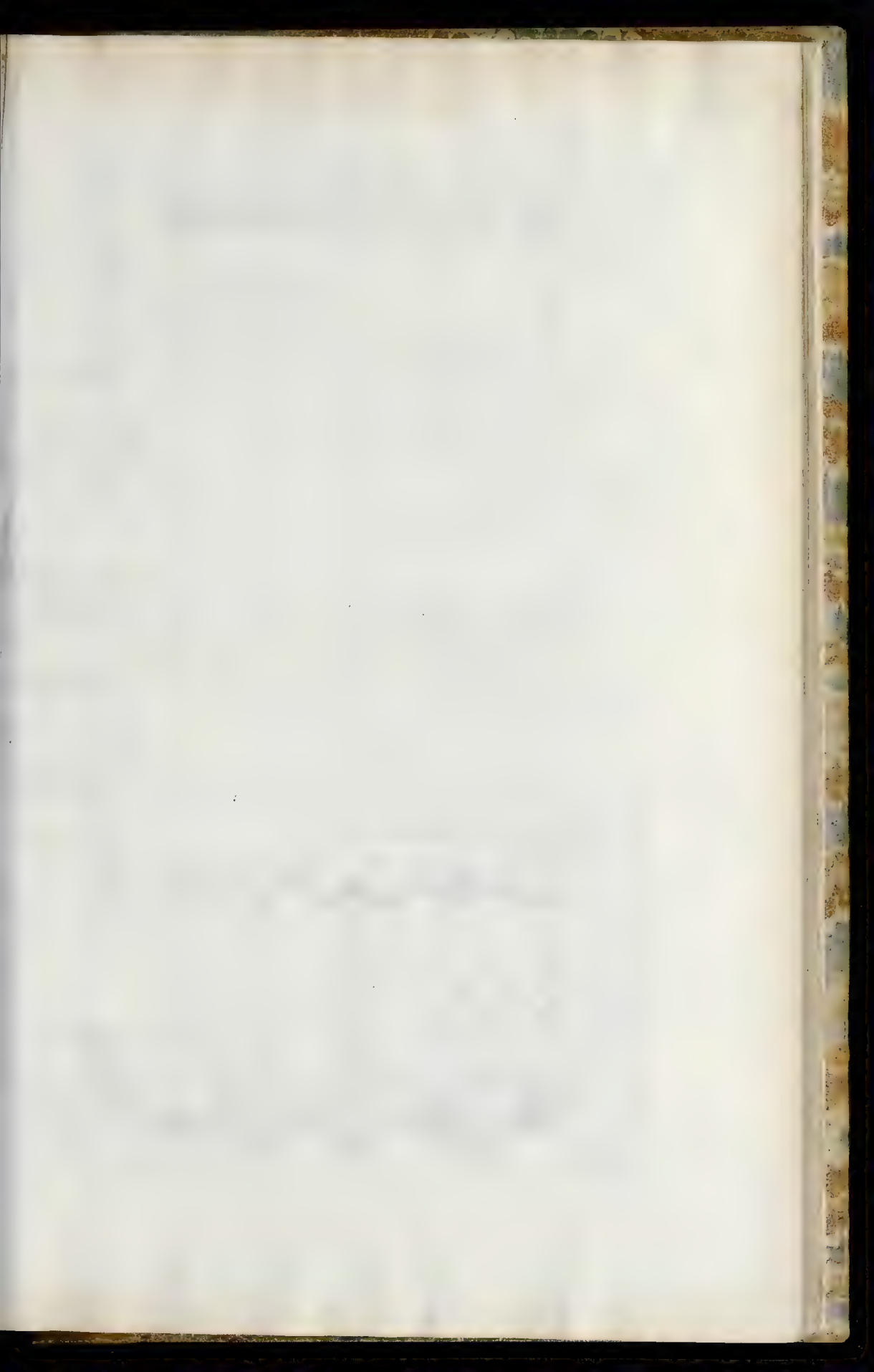
The shafts fig. VI, VII, and VIII. are the same shafts completed, whereby their effect may be adjudged.

PROBLEM XIV.

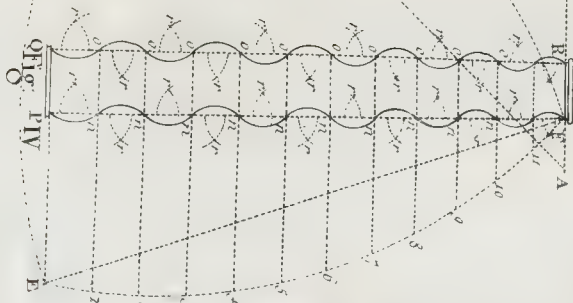
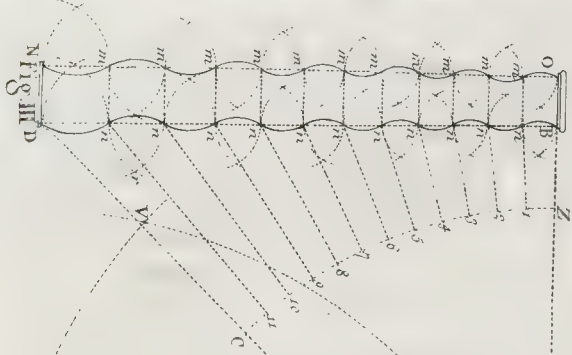
PLATE VIII.

How to divide the breadth of any pillaster into its flutes and fillets, and to delineate the geometrical upright of the same.

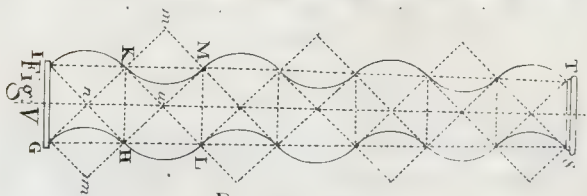
1. The general received proportion for dividing the breadth of a pillaster, is to divide every pillaster into seven flutes and eight fillets, and that the breadth of e-



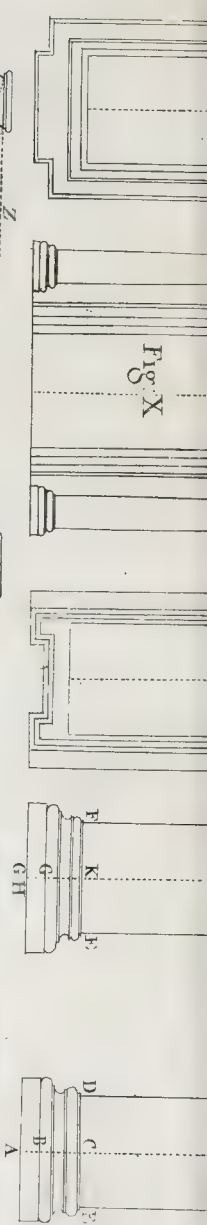
Corinthian Shaft

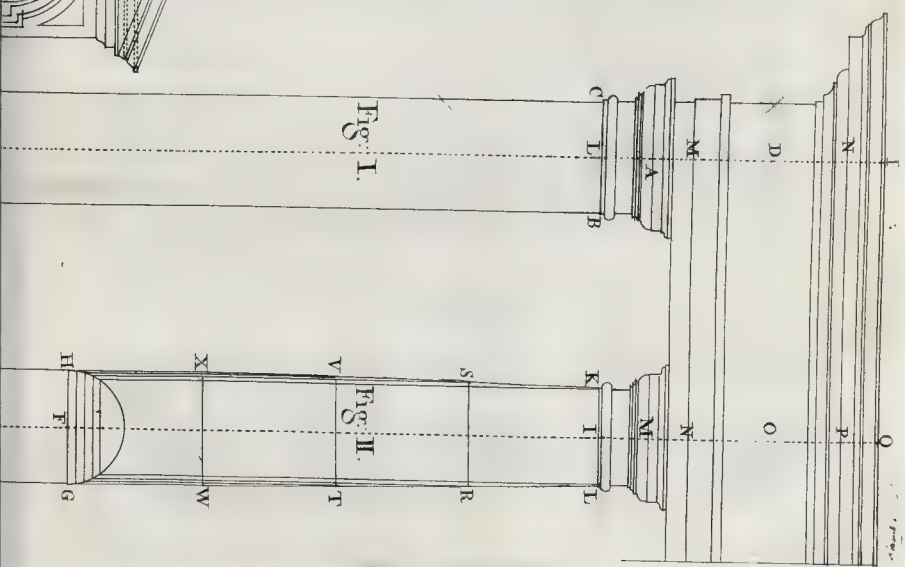
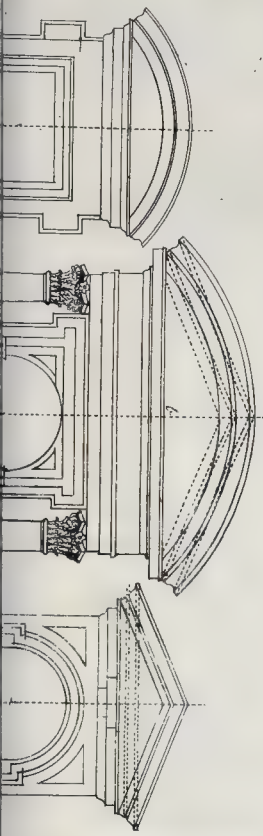
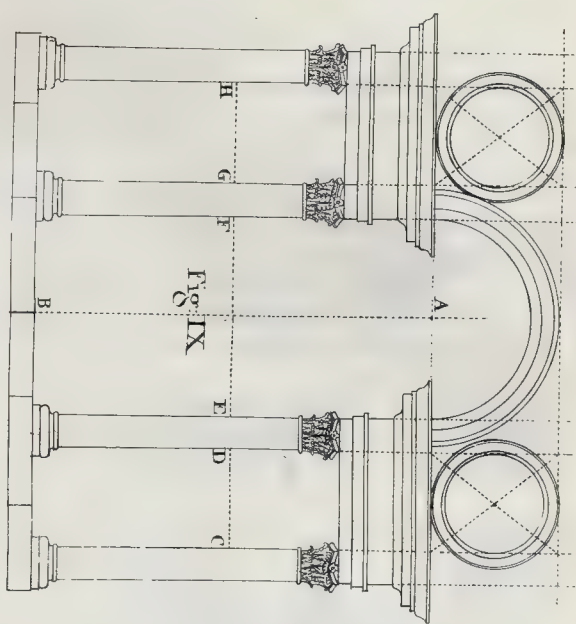
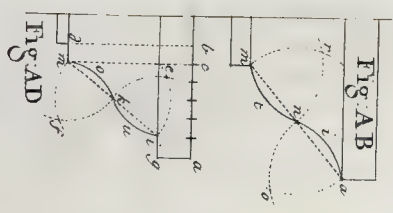


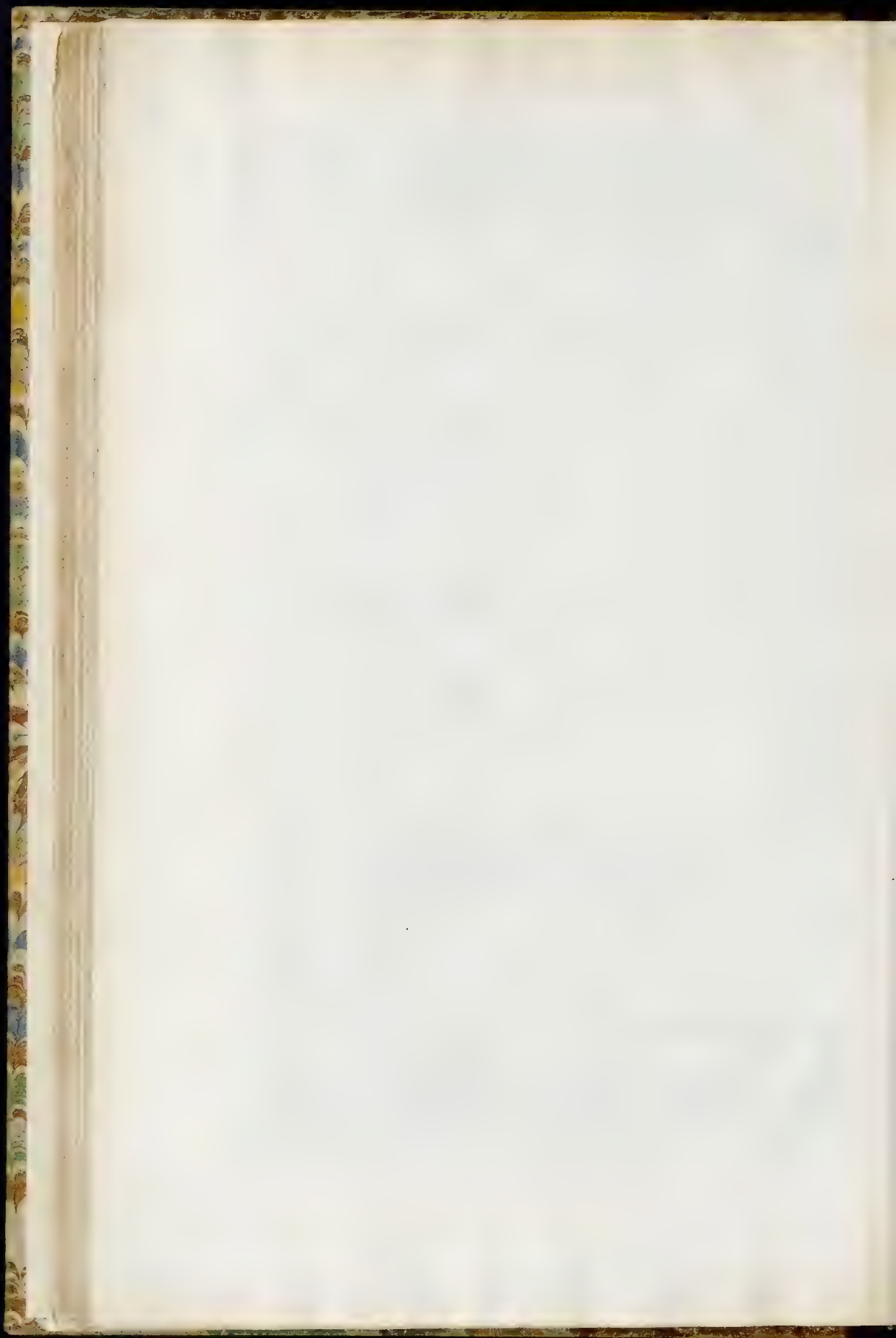
Ionick Shaft



Doric Shaft







very fillet contain $\frac{1}{7}$ part of the breadth of a flute, and thereby the breadth of every pilaster so fluted, is divided into 29 equal parts, *viz.* eight equal parts contained in the eight fillets, and twenty one equal parts in the seven flutes, each containing three, and thereby every fillet is equal to $\frac{1}{7}$ of a flute as aforesaid. This being well understood, we'll now proceed to the geometrical construction thereof. Fig. XIX.

PLATE VIII.

Let the line F G be the given breadth of a pilaster, to be divided into its flutes and fillets, as aforesaid.

1. Draw a line at pleasure, as A B.
2. With any small opening of the compasses, set off 29 times of that opening, beginning at any part thereof, as at B, and ending at A, as in the figure.
3. Having thus set off 29 equal parts on the line A B, the next work is to make an equilateral triangle therefrom, which thus perform.
On the point A, with the distance A B, describe the arch B a, and with the same distance on B, describe the arch A a, intersecting the former in the point C, and draw the lines A C and C D.
4. From the angle, or point C, draw right lines through all the 29 divisions marked 1, 2, 3, &c. and continue them infinitely, and thus have you prepared in effect an instrument that will at once divide the breadth of any pilaster that may be given, as shall appear by the example in hand.
5. Take the given line F G in your compasses, and set that distance from C to E, and from C to D, and draw the line D E; and because the figure is equilateral, therefore D E is equal to the given line F G, and by the lines C o, C o, &c. drawn through the 29 divisions, is divided into 29 equal parts also, which is the division of the pilaster required.

Operation.

1. Erect the perpendicular E H, which represents one side of the pilaster.
2. The first fillet being equal to $\frac{1}{29}$ of D E, therefore at the distance E b, draw b b parallel to E H, and it shall be the first or outside fillet.

3. As

Fig. XIX.

3. As every flute is equal to three fillets, therefore number three equal parts from b to c , and draw cc parallel to bb , and it shall be the first or outside flute.

4. At the distance of one division from c to d , draw dd for the next fillet, and also at the distance of three divisions from d to e draw ee for the next flute, and in the same manner, taking one division for a fillet and three for a flute, you will complete the flutes and fillets of the pillaster, as required.

N B. The depth of every flute in the pillaster is $\frac{1}{3}$ the breadth of the flute, therefore to describe the circular termination, set up $\frac{1}{6}$ of the breadth of the flute from x to z and that will be the center of the curve that terminates the flute cc , and the like of all others.


 'Tis to be observed (as I said before) that in respect to the figure being equilateral, the breadth of any pillaster may thereby most readily be divided, be the same but the tenth of an inch, or 1000 feet, &c. and therefore of universal use.

Fig. XIX.

The line $M N$ is the breadth of a smaller pillaster, which is divided in the same proportion and by the very same rule, and is inserted to shew the reason of the figure without any more words, to which I refer you.

PROBLEM XV.

To divide the basis, or plan of the shaft of a column into its 24 flutes, and 24 fillets.

The number of flutes were formerly limited to every order, the dorick being allowed 20, and the ionick 24. But that limitation has been dispensed with, with divers of our modern architects. In this example 'twill be sufficient to divide a semicircle, or the semi-basis of the shaft, instead of the whole, the last being but the first repeated.

Practice.

Practice.

1. Let B D be the diameter of the basis of a column given.

2. Divide the same into two equal parts in A, and thereon, with the distance A B, describe the semicircle B C D.

3. Divide the same into two quadrants by the perpendicular A C, and divide each quadrant into 12 equal parts, and draw the lines *a, a, a, a, &c.* through the same. And thus is the semi-basis prepared for the description of the flutes and fillets.

4. Divide any of the 12 parts (as B α) into eight equal parts.

5. Take three of those eight equal parts in your compasses, and on those points where the lines *a, a, a, &c.* intersect the semicircle B C D, describe the several arches *i, i, i, i, &c.* which shall be the flutes, and intervals of the fillets, as required.

Fig. XX.

PROBLEM XVI.

To divide the basis, or plan of the shaft of a column, into its 24 flutes without fillets, as is usual in the dorick order.

I shall here (as in the last) make use of the semi-basis only.

Fig. XX.

Practice.

1. Complete the semicircle B C D, and divide the same also into 12 equal parts, by the lines *n, n, n, &c.*

2. Divide any one of those parts, into eight equal parts, as the part 1 and 2.

3. From the several points where the lines *n, n, n, &c.* intersect the semicircle, on those several lines set off two of those eight parts, as at the points *o, o, o, o, &c.* which are the centers of each flute. Therefore on those points, with the distance *o 1* or *o 2, &c.* describe the several arches, and they will complete the flutes of the semi-basis, as required.

Fig. XX

PROBLEM XVII.

To describe on a paper drawing, wall, &c. the geometrical upright of a column, with its flutes and fillets.

To describe the geometrical upright of a column, is to shew in what manner the flutes and fillets diminish in their breadth, as they approach the extrem parts of the column.

Practice.

Fig. XX.

If from the intersection of the flutes and fillets, you draw the lines $r, r, r, r,$ &c. perpendicular to $B D$, and complete their terminations with circular lines, as in the figure, they will complete the geometrical upright of that part, as required, and every flute and fillet have its due breadth, according to the rules of perspective.

PROBLEM XVIII.

To describe (in the aforesaid manner) the geometrical upright of a column, with its flutes only, as often used in the dorick order.

Practice.

Fig. XX.

1. If from the intersection of the flutes in the semi-circle $B E D$, you draw the lines $s, s, s,$ &c. perpendicular to $B A D$, and complete their terminations with circular lines, as in the figure, they will complete that geometrical upright, as required.

PROBLEM XIX.

To divide the base, or plan of the shaft of a column into its 20 or 24 flutes, according to Vitruvius.

Practice.

Fig. XXI.

1. On A describe the base of the shaft, as the circle $B a b D E$.
2. Divide the circumference into 20 or 24 equal parts by the lines $n, r, r, r,$ &c..
3. Make

3. Make ia and ib , each equal to $\frac{1}{2} im$, and draw the right line ab .

4. Complete the geometrical square $adcb$, and draw the diagonals ac and db , intersecting each other in n , the center of the flute $ao b$.

5. On A , with the distance An , describe the circle $nrrr$, &c. intersecting the lines r, r, r , &c. which are the 24 centers of the 24 flutes, whereon, with the radius nb or an , you may complete the whole, as required.

PROBLEM XX.

To divide the base, or plan of the shaft of a column into its 20 or 24 flutes, according to Vignola.

Practice.

1. On E describe the base of the shaft, as the circle $AdbBD$.

Fig. XXII.

2. Divide the circumference into 20, or 24 equal parts by the lines e, e, e , &c.

3. Make ib and id , each equal to $\frac{1}{2} ib$, and draw the right line db .

4. Complete the equilateral triangle dab , and then will the angle a be the center of the flute dnb .

5. On E , with the distance Ea , describe the circle eee , &c. intersecting the lines e, e, e , &c. in the points e, e, e , &c. which are the 24 centers of the 24 flutes, whereon, with the radius ab or ad , you may complete the whole, as required.

N. B. That although both the shafts in these examples are divided into 24 flutes, yet you are to understand that neither *Vitruvius* or *Vignola* made use of any more than twenty; therefore if you are willing to follow their rules therein exactly, you must divide the circumference of the shaft into 20 parts, instead of 24, and then proceed in all other respects, as in the preceding problems, and thereby you will complete the whole, as required.

PROBLEM XXI.

To divide the base of the shaft of a column, into its cabled flutings.

Practice.

- Fig. XXIII. 1. On A describe the base of the shaft, as the circle *a a a*, &c.
2. By problem XV. hereof, delineate the flutes and fillets thereof.
3. On *o o o*, &c. with the radius *o, a, o, a*, &c. describe the arch *r a s*, &c. and thereby you will describe the cabled fluting, as required.

PROBLEM XXII.

To divide the base of the shaft of a column into its 24 flutes and 24 fillets, after the manner of the columns within the Pantheon.

Practice.

- Fig. XXIV. 1. Describe a circle representing the base of the shaft, and divide the circumference thereof into 24 equal parts by the lines *a, a, a*, &c.
2. Divide each part into 5 equal parts, of which give 4 to every flute, and one to each fillet.
3. Make the depth of each flute, equal to the breadth of every fillet, and then will the whole be completed, as required.

Fig. XXV. is the plan of the dorick shaft cut into cants instead of flutings without any cavity, first taught and practiced by *Vitruvius*, which I here insert, to shew the young student what a great variety there is contained in the form and manner of fluting columns.

PROBLEM XXIII.

To describe the ionick voluta according to the antique manner.

PLATE IX.

Practice.

- Fig. I. 1. Delineate the Abacus B A, and from the point $28\frac{1}{2}$, let fall the cathetus, perpendicular, and delineate the hollow of the voluta B B, the ovolo B D, the astragal B E, and the cincture or annulet B F.

2. Draw

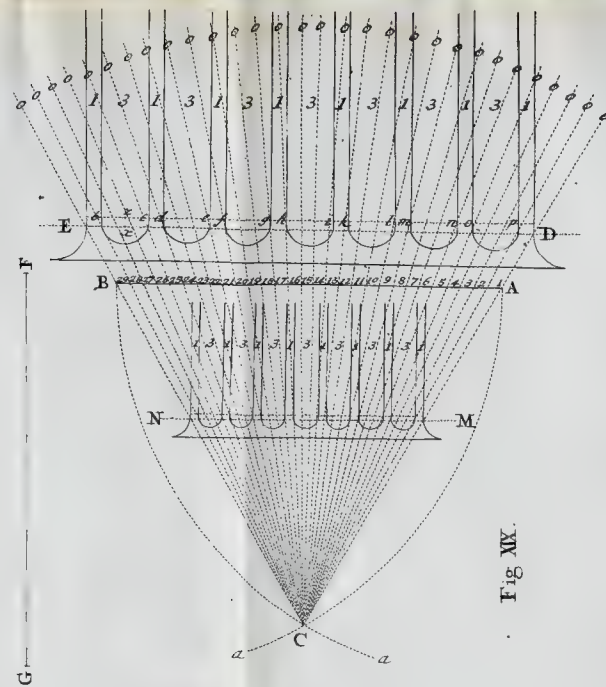


Fig. XX.

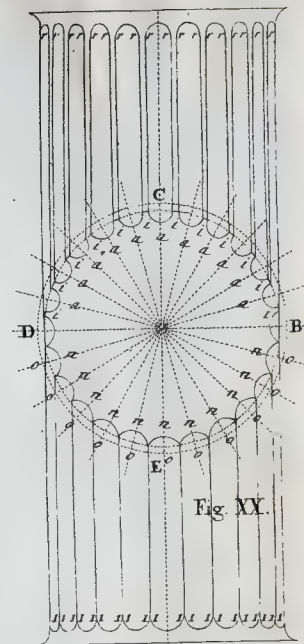


Fig. XXV.

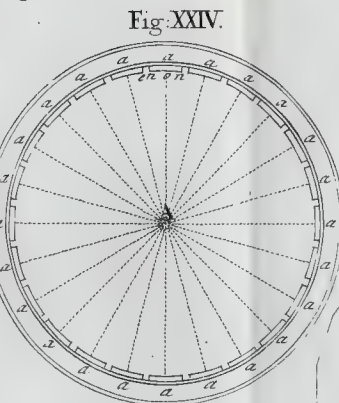


Fig. XXIV.

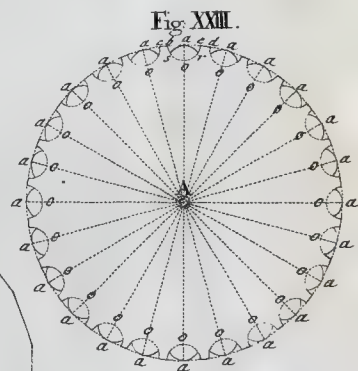


Fig. XXIII.

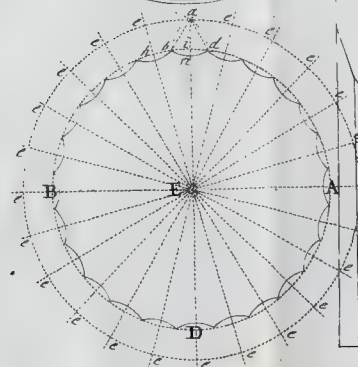


Fig. XXII.

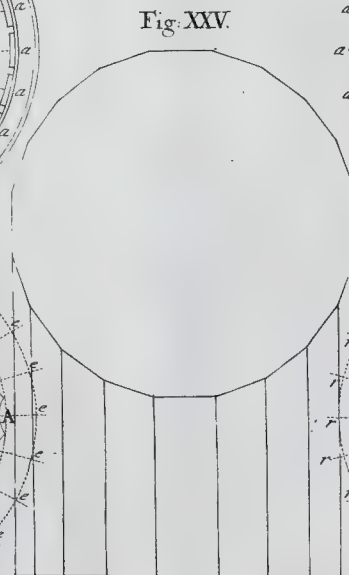


Fig. XXI.

The Eye of *S. voluta*

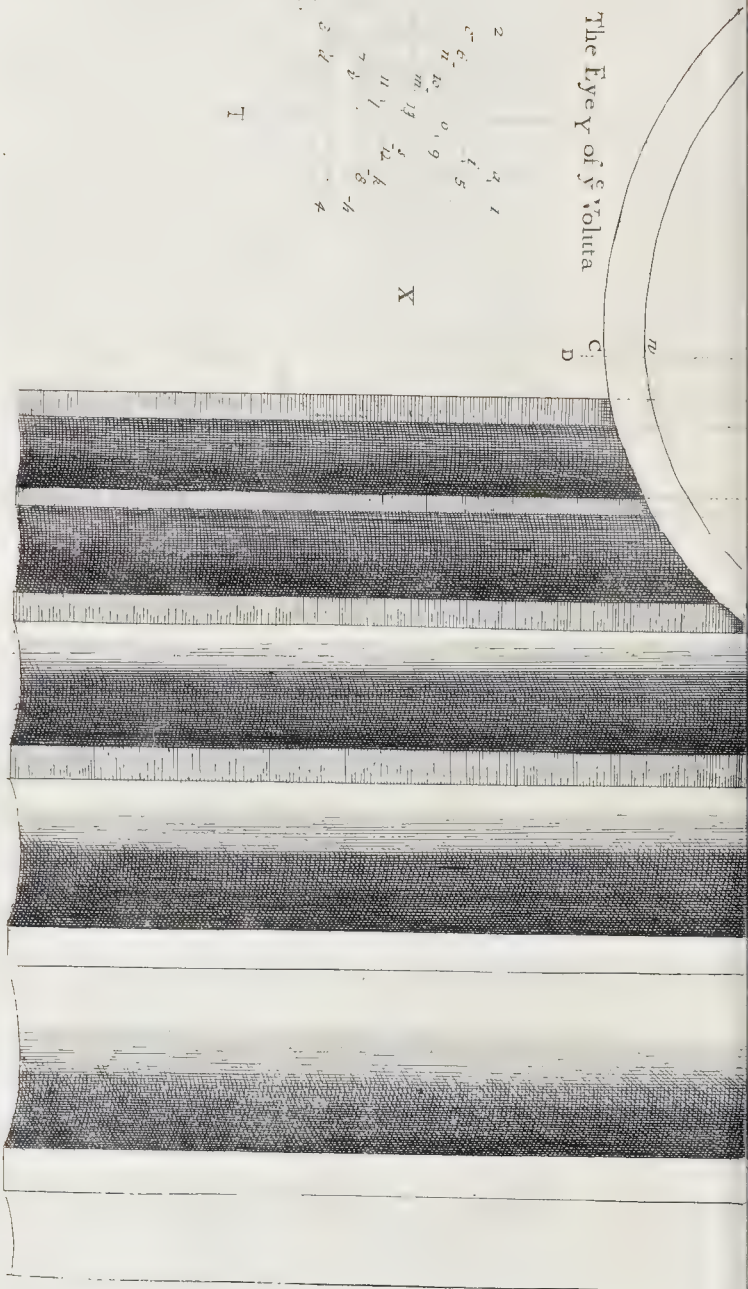
C
D

Z

Fig. II.

T

X





Cathetus

BB



Fig. 1.

三

BE

B F*



2. Draw the right line F B so as to pass through the middle of the astragal B E, intersecting the cathetus in the point 1 3.

3. On the point 1 3, with the distance 1 3 Y, describe the circle or eye of the volute Y X Z, and draw the geometrical square Y X T Z.

4. Bisect Y X, X T T Z and Z Y in the points 1, 2, 3, 4, and draw the geometrical square 1 2 3 4, and also the diagonals 1 3 and 2 4.

5. Divide each diagonal into 6 equal parts at the points 5, 9, 11, 7, 6, 10, 12, 8.

6. Make 1 a equal to $\frac{1}{6}$ of 1 2, as also 2 c, 3 d, 4 b, 5 i, 6 n, 7 v, 8 k, 9 o, 10 m, 11 t, 12 s, and thus will you have divided the eye of the volute into its proper centers, on which you may describe it as follows, viz. on the point 1, with the opening 1, 2 8 $\frac{1}{2}$, describe the arch 2 8 $\frac{1}{2}$ B, and on the point a the arch n m, also on the point 2 the arch B C, and on c the arch m w; likewise on the point 3 the arch C F, and on d the arch w E, and so by removing to the other centers 4 b, &c. you will complete the whole voluta, in the most elegant manner as can be desired. And that the young student may have a perfect idea of the centers thereof (which in number are 25) I have in fig. II. described the eye of the volute at large, wherein the numerical figures denote the centers of the exterior line, and the small italic letters the centers of the interior, which in an instant will enable him to delineate the same with great ease and delight.



SECT. II.

Of the Derivation, Proportion, Diminution and Inter-columnation of the Tuscan, Dorick, Ionick, Corinthian and Composite Orders of Architecture.

I. Of the Tuscan order.

THE Tuscan or rustick order (saith *Vitruvius*) is the most simple and strongest of all the orders of architecture, it hath no ornaments and but few mouldings. This order was first made by the *Asiatic Lydians*, who
 V are

are said to be the first that inhabited *Italy*, and brought it into that part, called *Tuscana* or *Tuscany*, and from thence was called the *Tuscan* order.

And altho' this order is of all others the most plain and simple, yet many noble structures have been built therewith, as the ports and entrances into cities, amphitheatres, bridges, &c. and particularly that famous column of the *Trojans*, that of *Antoninus* at *Rome*, and likewise that of *Theodosius* at *Constantinople*, which are all remaining to this day.

The proportion, diminution and intercolumnation of this rural order is as follows.

1. The shaft only without its base and capital is in length six diameters of the shaft's base, and the height of the base and capital each a femidiameter thereof.
2. The entablature of this order is seldom less than $\frac{1}{4}$ of the shaft's height.
3. The pedestal hath two diameters of the shaft's base for its height, and the shaft at the upper part diminishes $\frac{1}{4}$ of its diameter at the base.
4. The intercolumnation of this order may be made very large, by reason the architrave is generally made of wood, but the most usual is about 4 diameters of the shaft at the base.

II. Of the Dorick order.

The Dorick order is of all others the most grave and masculine, and the most agreeable to nature. *Scamozzi* calls it Herculean aspect, in regard to its excellent proportion. This order had its original and name from the *Dorians*, a Grecian people of *Asia*, or as some say, from *Dorus* King of *Achæsis*, who is said to be the first that built at *Argos*, and dedicated a temple of this order to *Juno*.

The proportion, diminution and Intercolumnation of this noble order, is as follows.

1. The shaft, exclusive of the base and capital (when alone) is in length seven diameters, but when in porticos and mural work but six.
2. The height of the capital is a femidiameter of the shaft's base, as also the Attick base, &c. when used herein.

in. For you must note, that this order was anciently made without any base, as may be seen by the geometrical profiles of the *Theatre of Marcellus*, the Bath of *Dio-cletian*, &c. at *Rome*, at the end hereof.

3. The entablature is generally two diameters in height, and is oftentimes enriched in the freize with triglyphes and metops. The shaft of this order is oftentimes fluted, with a short edge without any fillets, as laid down by *Palladio* and *Vignola*, in the preceding problems of sect. I. hereof. And as I said before, that the ancients, never used any base to this order, so 'tis also to be understood of pedestals; therefore when any are used herein, *Palladio* allows their height to be two diameters, and $\frac{1}{3}$ of the shaft's base.

4. The diminution of the shaft is $\frac{1}{7}$ of the shaft's diameter at the base. And the intercolumnation of this order is three diameters, except at such times when the distribution of the triglyphes and metops require something more or less.

III. Of the Ionick order.

The Ionick order is an exact mean proportion, between the delicate and the robust. *Vitruvius* compares it to a matron decently dress'd. It was first invented, or introduced by *Ion*, in *Ionia*, a province in *Asia*, and 'tis said that the Temple of *Diana*, at *Ephesus*, was built of this order.

The proportion, diminution, and intercolumnation of this decent feminine order, is as follows.

1. The shaft with its base and capital, were anciently but 8 diameters, which by the moderns was thought too little, and therefore to give it proper stature, they added one diameter, so that it now contains 9 diameters in height. The shaft is fluted with 24 flutes, with fillets between, whose breadths are equal to $\frac{1}{7}$ of a flute.

2. The entablature is $\frac{1}{7}$ of the altitude of the column, and its cornish is always adorn'd with denticules.

3. The height of the pedestal is two diameters and $\frac{2}{3}$, and its intercolumnation two diameters and $\frac{1}{4}$, which is the most elegant manner of intercolumnation, and by *Vitruvius* is called *Eusillos*.

Lastly, The diminution of the shaft is $\frac{1}{6}$ of the diameter at the base of the shaft.

IV. Of

IV. Of the Corinthian order.

The Corinthian order is the very pride and delicacy of all the other orders. It was first design'd by an architect of *Athens*, and executed at *Corinth*, a noble city of *Peloponnesse*, or *Morea*, from whence it had its original and name of Corinth in order.

The proportion, diminution, and intercolumnation of this beautiful order, is as follows.

1. The shaft with its base and capital is 9 diameters and a half, and sometimes 9 and $\frac{3}{4}$, and oftentimes 10 diameters in length. If the shaft be fluted, the flutes must be made according to problem XV. sect. I. hereof.

2. The height of the capital is one diameter of the shaft at the base, of which the abacus must be a sixth, or seventh part, and the remaining quantity being divided into 3 equal parts, the two lowermost is the true height of the first and second tour of leaves, and the third or uppermost part being divided into two equal parts, the upper part of those two parts shall be the extremes of the volutas and the lower the cauliculi.

3. The height of the entablature is $\frac{1}{7}$ of the column, including the base and capital, except when applied to great and magnificent buildings, as the *Roman Pantheon*, &c.

4. The height of the pedestal must be $\frac{1}{4}$ of the altitude of the column, and the diminution of the shaft $\frac{1}{7}$ of the diameter at its base.

5. The intercolumnation is two diameters and $\frac{1}{4}$, as in the preceding order of the Ionick.

V. Of the Composite order.

The Composite order, is of Roman extraction, and by many called the *Italian* order, and oftentimes the *Roman* order. 'Tis compos'd of the Ionick and Corinthian orders, and therefore is called the compos'd order.

The proportion, diminution and intercolumnation of this order, is as follows.

1. The shaft, with its base and capital, is ten diameters in length, or height; and its entablature $\frac{1}{4}$, or $\frac{1}{5}$, thereof.
Its

its diminution at the head of the shaft is $\frac{1}{8}$ of the diameter at the base, and its intercolumnation one diameter and $\frac{1}{2}$, or $\frac{3}{4}$.

The height of the pedestal is generally equal to $\frac{1}{3}$ of the column's altitude, and its base is either attick, or a compound of the attick and ionick.

And altho' these proportions of all the five orders are thus established, yet not with so great a strictness, but that the architect may vary therefrom, upon just occasions, as the grandeur and conveniency of a building may require.



S E C T. III.

Of Architectonical Axioms and Analogies.

I. Of doors.

THat the height of all doors be double their breadth.

That doors in general be proportional to the magnitude of the rooms.

That the breadth of inner doors be never less than 2 feet $\frac{1}{2}$, nor more than 6 feet.

That the doors of the 2d story be placed exactly over the doors of the first, and the like of the 3d, &c.

That an arch of brick or stone be turned over every door, to discharge the weight that presses upon them, which oftentimes ruins the structure.

II. Of windows.

That the magnitude and number of windows be proportional to the rooms that they are to illuminate.

That the height of every window in the first story be double its breadth, with the addition of $\frac{1}{4}$, $\frac{1}{3}$ or $\frac{1}{2}$ part, as found to be necessary.

That the height of the windows in the 2d story be $\frac{11}{12}$ of the first, and the height of the attick or 3d story $\frac{1}{4}$ of the second story.

That windows be not placed too near the angles of any building, that thereby the structure be not weaken'd.

Of Architectonical Axioms and Analogies.

That over every window be turn'd an arch to discharge the weight that lies over them.

That no girder be laid over any door or window, but always on the most substantial part of the brick or stone peers, &c. that solid may rest upon solid.

That *Venetian* windows have their proportions, as follow, *viz.* (fig. IX. plate VII.) that the height A B be equal to twice E F, and that G H and C D be each equal to $\frac{1}{2}$ E F.

That the centers of all pediments be placed down the central line at the distance of $\frac{1}{2}$ the length of the corona. So the point *c* of fig. X. plate VII. is the center of that pediment, being the distance of *a*, *b*, set down to *c* and the like of all others in general.

III. Of gates.

That the breadth of principal gates of entrance be never less than 7 feet $\frac{1}{2}$, nor more than 12 feet.

That the height of principal gates of entrance be never less than their breadth and $\frac{1}{2}$, nor more than twice, which is the best proportion.

IV. Of halls.

That the length of halls, be not less than twice their breadth, nor more than three times.

That the height of halls, whose cieling's are flat, be not less than $\frac{2}{3}$ of the breadth, or more than $\frac{3}{4}$ of the length.

That the height of halls whose cieling's are arched be not less than $\frac{5}{6}$, nor more than $\frac{11}{12}$ of their breadth.

V. Of galleries.

That their site be towards the *North*, on account that the *North* light is the best for painting, pictures, &c.

That the breadth of galleries be not less than 16 feet, nor more than 24.

That the length of galleries be not less than 5 times their breadth, nor more than eight at most.

That the height of galleries be equal to their breadth, if with flat cieling's, but if arched, the breadth and $\frac{1}{7}$, $\frac{1}{4}$ or $\frac{1}{3}$.

VI. Of antichambers.

That the length of all antichambers be equal to the hypotenuse of a right angled plain triangle, whose legs are each equal to the breadth of the antichamber.

That

That the breadth of all antichambers be proportional to the whole structure. That the height of antichambers be not less than $\frac{2}{3}$ of the breadth, or more than $\frac{3}{4}$ of the length, when the cieling is flat, and when arched, to be not less than $\frac{5}{6}$, nor more than $\frac{11}{12}$ of their breadth.

VI. Of chambers.

That all principal chambers of delight be placed towards the best prospects of the country, and if possible to the *East*.

That the length of chambers never exceed the breadth and $\frac{1}{5}$ of the breadth; therefore the length may be the breadth exactly, or the breadth and $\frac{1}{8}$, $\frac{1}{7}$, $\frac{1}{6}$ or $\frac{1}{5}$.

That the height of all chambers of the first story, whose cielings are flat, be not less than $\frac{2}{3}$ of the breadth, or more than $\frac{3}{4}$ of the length.

That the altitude of chambers in the second floor be $\frac{11}{12}$ of the first story.

That the altitude of the chambers in the third floor be $\frac{3}{4}$ of the second.

VII. Of Floors.

That the floor of every story in a building be truly level throughout, so as to pass out of one room into another, without going up or down stairs, as is common in many buildings.

That the height of the level of the first (or ground) floor, be never less than one foot, nor more than four feet.

VIII. Of chimneys.

1. Of hall chimneys.

That the proportion of hall chimneys be as follows, *viz.* Their distance between the jaums from 6 to 8 feet; their height from 4 feet $\frac{1}{2}$ to 5 feet; their projection from 2 feet $\frac{1}{2}$ to 3 feet at most; the breadth of the jaums from 8 to 24 inches or more, as occasion may require, according to the order that the chimney is adorned with.

2. Of chamber chimneys.

That the proportion of chamber chimneys be as follows, *viz.* their breadth from 5 to 7 feet, their height 4 feet $\frac{1}{2}$, and projecture 2 feet and $\frac{1}{2}$.

3. Of

3. Of chimneys in studies, &c.

That the proportion of chimneys in studies be as follows, *viz.* their breadth from 4 to 5 feet at most; their height 4 feet $\frac{1}{3}$, and projecture 2 feet $\frac{1}{2}$.

That the funnels of chimneys of chambers, or studies, be not narrower than 10 inches, or wider than 15, which is a good size for kitchen chimneys.

IX. Of the funnels of chimneys.

That the funnels of chimneys be carried a sufficient height above the ridge, that reflex winds may not repulse the smoke.

That the funnels of chimneys be not wide, whereby the wind may drive down the smoke into the room, or too narrow, where it cannot have a free passage.

That the funnels of chimneys be truly perpendicular, otherwise the smoke cannot freely pass, and thereby will be offensive.

That no timber, joist, &c. be laid nearer to the jaums than one foot.

That no trimming joists be laid nearer than 6 inches to the back of any chimney.

That the funnels of all chimneys have not any timber, as girders, joist, &c. laid therein, otherwise the building will be in danger of being reduced to ashes.

X. Of joists, rafters, and girders.

That the greatest distance that joists, or rafters, are laid from each other, do not exceed 12 inches, and quarters 14 inches.

That no joist bear at a greater length than 12 feet, or single rafters more than 10 feet.

That the length of joists laid in the wall be not less than 9 inches, and no girder be less than 12 inches.

XI. Of stair cases.

That stair cases be spacious, light and easy in ascent.

That the breadth of stair cases be not less than 4 feet, or more than 12 feet.

That the height of steps be never less than 4 inches, or more than 6.

That the breadth of steps be never more than 18 inches, or less than 12 inches.

XII. Of

XII. Of materials, &c.

1. That money and materials be always ready from the beginning, or laying of the foundation, to the turning of the key when the whole is completed.

2. That great care be taken in the goodness of foundations, and that they be truly level.

3. That the thickness of all foundations be double to the infistent wall.

4. That the most heavy materials be employed in the foundations.

5. That all walls diminish in thickness, according to the nature and height of the structure.

6. That every wall be perpendicular.

7. That such bricks as are not well burnt, be not used in any building.

8. That the depth of all fabricks in the ground that have cellars, vaults, &c. be $\frac{1}{7}$ of the whole height, and those that have no cellars to be $\frac{1}{6}$ of the height.

9. That the kitchen be spacious and light, and as remote from the parlor as possible, and to be under ground ; as also the pantry, bake-house, still-room, buttry, dairy, and servants offices in general.

10. That cornishes do not project too far out from the building, whereby the windows be darken'd.

11. That of all kind of arches none is so strong as the semicircle.

12. That the depth of all rusticks be never more than 1 foot, nor less than 9 inches.

13. That the thickness of pillasters, of doors and windows, be not more than $\frac{1}{5}$ of their aperture, nor less than $\frac{1}{6}$.

14. That the projecture of pillasters in general, be $\frac{1}{6}$ of their thickness.

15. That the roofs of all buildings be not too heavy, or too light, and that the interior walls support part of the same.

16. That convenient cisterns be well placed, plentifully to furnish every office with water, and that proper machines be made to raise the same therein.

Lastly, That convenient drains, to carry away soil, &c. be well contrived, and secretly placed, with vents to discharge the noisome vapours.



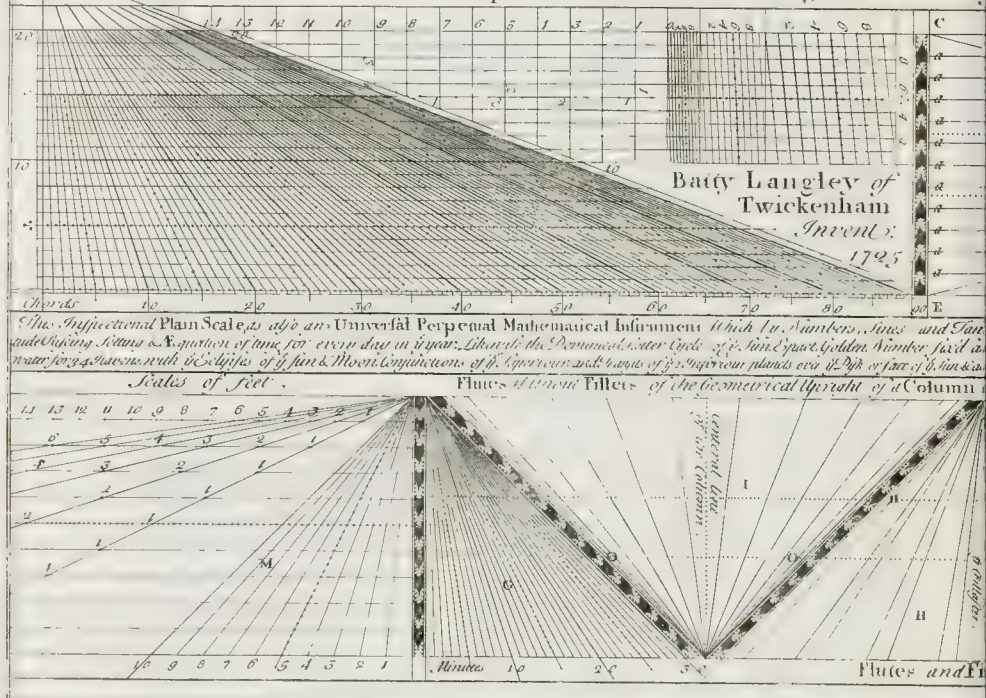
S E C T. IV.

P L A T E X.

Of the Description and Use of an inspectional plain Scale, for delineating Architecture, Gardening, &c.

THIS scale being designed but for the drawing of architecture and gardening, it is therefore made to such a breadth and length as is fuitable to the magnitude of any draught whatsoever. And although this instrument was designed for drawing only, yet it may, with a great deal of ease and delight, be applied to the practice of architecture, which at the end hereof I shall demonstrate. In the use of this instrument 'tis required to have such a table as is used with a drawing table, well known by all architects, &c. and the breadth thereof must be exactly equal to $\frac{1}{2}$ the breadth of the instrument. The lines on this scale are of two kinds, *viz.* parallel, as the lines *a, a, a,* &c. and central, as the lines of the trigons G H I K L, and the chords over the trigons M G I. The parallelogram C D E F, represents $\frac{1}{4}$ of a pillaster or column, and C E its semidiameter, and consequently either C D or E F, the central line of the pillaster or column. The diagonal scale at the end thereof is treble; for *first* you have an inch in a hundred parts, *secondly* an $\frac{1}{2}$ inch, and *lastly* $\frac{1}{4}$ of an inch in the same proportion. Which scales are of great use in delineating maps, that were measured with *Gunter's* chain, which is divided into 100 links. The trigon adjoining thereunto hath its base divided into 90 unequal parts, and is a line of chords from which, to the center, are drawn right lines, which divide the several parallels therein in the same proportion, and thereby you have 20 lines of chords to 20 different radius, &c. The diagonal lines C F and E D are drawn, to set thereon the half length of any column or pillaster. The diagonal E D is to be used, when any question is to be answered by the trigons I K, and the other diagonal C E, when by the trigons M G H L. The trigon G hath both its sides equal to the semidiameter C E, whereof the outward is divided into 30 equal parts, each representing a minute, from which are central lines





Architecture. Gardening. &c.

Central line of the Column or Pillaster.

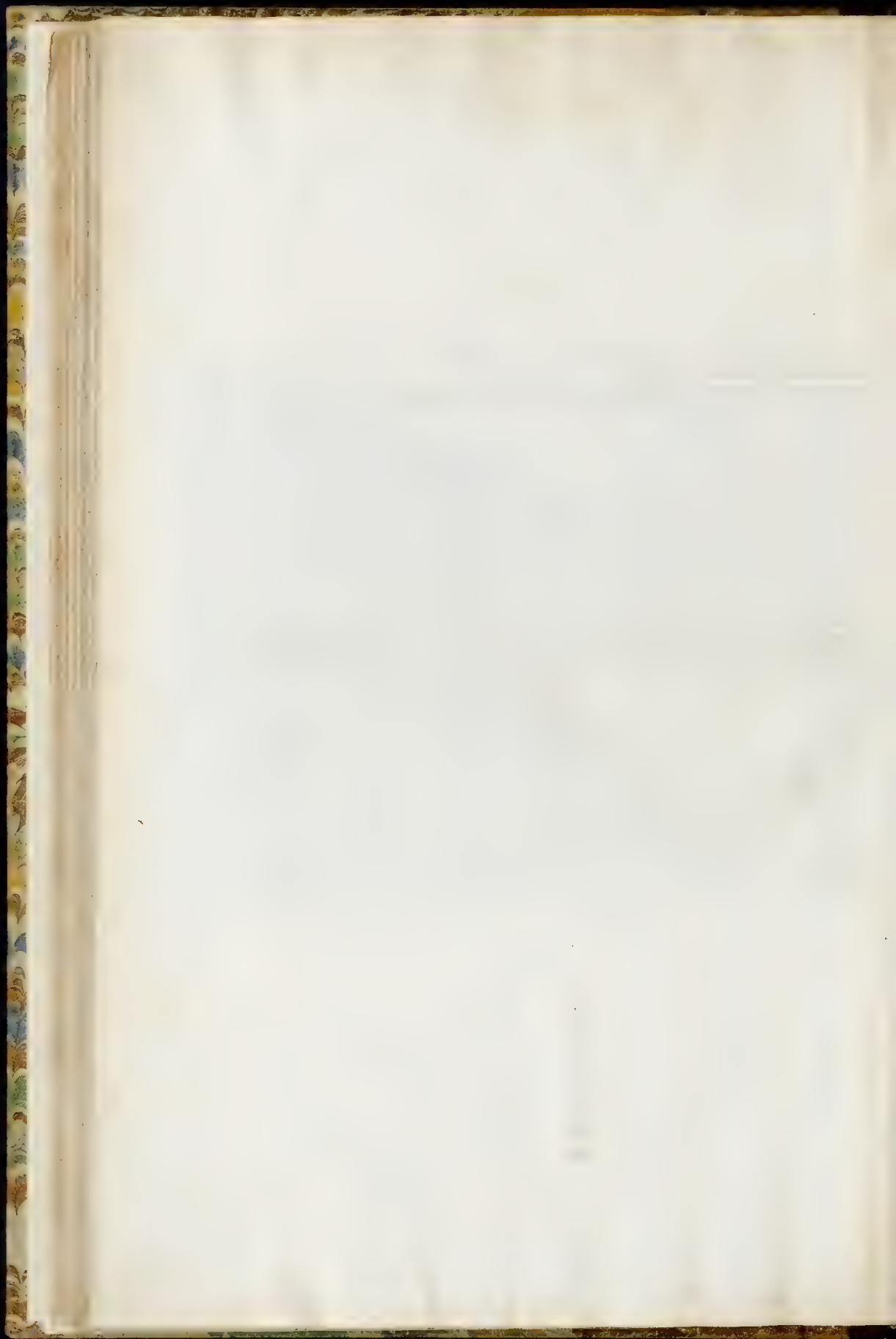
Central line of the Column or Pillaster

Solves all Arithmetical, Trigonometrical, and Astronomical questions &c. also the Suns Place, Right Ascension, Declination, Longitude, Azimuth, &c. and then returns sin and full moon, her rising, setting, and place in the Zodiac, Southings, and time of day.
Mathematical Instruments Made by Order, sold at the Barber & Globes over against Exeter Exchange in the Strand LONDON.

Scales of Feet and Inches.

of Pillasters

10 11 12 13 14 15 16 17 18 19 20



drawn to the center, which divide all parallel right lines drawn therein, in the same proportion.

The trigon H hath its side opposite to the center divided in such proportion, as the whole breadth of a pillaster is divided by its 8 fillets and 7 flutes; from which divisions are lines drawn to the center, which also divide any line that is parallel to the outside, in the very same proportion.

The trigons I and K, are divided after the same manner, as that of I in the division of the diameter of a column with flutes only, and that of K with its flutes and fillets.

The trigons L and M are made, to furnish the young student with scales of all sizes, either for measures of feet and inches, as that of L, or feet only, as that of M.

PROBLEM I.

The height of a pillaster, or column, being given, to find the semidiameter thereof, divided into its 30 min. by which the whole pillaster, or column, with its architrave, freize, and cornish is measured.

Let A B be the half height of a column given, to find the semidiameter divided into minutes.

Practice.

1. Lay your te-square on the instrument, and taking A B in your compasses, move the edge of your square to the outside at C, and at C make a mark on the square exactly over the line C E, and from that mark set off the distance of A B taken in your compasses, on the edge of the square as at X.

2. Slide back the square, 'till the point X lie over the diagonal C F, in the point Y, and then shall that edge of the square that lies over the trigon G be the semidiameter of the given column, and the central lines be divided into 30 min. as required.

☞ 'Tis best, when the diameter is thus found, to draw a fine line with a black lead pencil by the side of the square, over the whole breadth of the trigon, and then you may take away the square and work from the divisions of the black lead line, as occasion requires.

PROBLEM

PROBLEM II.

The height of a pillaster being given, to find its breadth, and division into 7 flutes and 8 fillets.

Practice.

1. Let it be required to find the breadth and division of the pillaster, whose $\frac{1}{2}$ height is equal to the aforesaid given line AB.
2. Place the point X on Y (as before) and then will the other edge of the square cut the trigon H in the point *nn*.
3. The line *nn* is the breadth of the pillaster, and its divisions, by the central lines, are the true breadths of every flute and fillet, as required.

PROBLEM III.

The height of a column being given, to find the diameter, and measure (or true breadth) of every flute and fillet, contained in the geometrical upright of the same.

The trigon for flutes and fillets is the trigon K, therefore you must use the diagonal E D.

Let the height of the column be (as afore) equal to twice the given line A B.


1. Place the $\frac{1}{2}$ height CX at Z, then will the other edge of the square cut the trigon K in the points *nn*.
2. The line *nn* is the diameter, or breadth, of the column, and its divisions by the central lines, the true breadths of every flute and fillet, as required.

PROBLEM IV.

To find the true measures of the flutes contained in the geometrical upright of a column, that is fluted without fillets (as often practiced in the dorick order) to any height assigned.

Let the height of the column be as aforesaid, equal to twice the given line A B.

1. Place the point X over Z, then will the other edge of the square, cut the trigon I in the points *o* and *o*.
2. The line *oo* is the diameter of the column, and its divisions, by the central lines, are the true breadth of every flute, as required.

 *Note*, That to find the breadth, or magnitude of the flutes and fillets, &c. at the top of the column, where they are narrower than at the base, you must place the
the

the diameter upon the respective trigon, so as to intersect the sides and be parallel to the base hereof, and the lines of the trigon will divide the diameter into its true divisions of flutes and fillets, &c. as required. And the like of any other part of the column whatsoever.

PROBLEM VI.

To reduce any part of a line, as a model, minute, &c. into feet and inches, and thereby make this instrument universal in practice.

Let $a b$, in the trigon L , represent 5 inches, and 'tis required immediately to find a scale of 12 inches suitable to it, whereby any part may be measured by feet and inches.

1. Take the line $a b$ in your compasses.
2. Fix the edge of the square to the center H of the trigon L , and set off the line $a b$, on the edge of the square from H to i .
3. Move the square towards the line 1, 2, 3, &c. 'till the point i exactly lie over the line $H 5$ (as on the point E) and draw by the edge of the square the line $I K$, which by the 12 central lines will be divided into 12 equal parts, (5 of which are equal to the given line $a b$) and is the scale of 12 inches suitable, or proportionable to the line $a b$, as required.

A second example.

Suppose $C E$ to represent 20 inches, how to find a scale of 12 inches proportionable thereunto.

Practice.

1. The $\frac{1}{2}$ of 20 is 10, therefore lay the edge of the te-square to H (as in the last example) and set off the $\frac{1}{2}$ of $C E$.
2. Move back the edge of the square till the point, or $\frac{1}{2}$ of $C E$, cut the line $H 10$.
3. The edge of the square being not moved, draw a line by the same through the trigon L , which by the 12 central lines will be divided into 12 equal parts, representing inches, and proportional to $C E$ that contains 20 inches, as was required to be done.

¶ When your column, or pillaster, contains any number of odd inches, radius or diameter, as 27, &c. take $\frac{1}{3}$, &c. thereof, as 9, &c. and find the scale
Z for

for that number, and that scale so found shall be the scale proportionable to 27, as required.

The trigon M is an infinite number of scales each divided into tenths, by the 10 central lines, as may be at once understood by a single view of the same. These decimal scales are of great use in measuring plans of gardening, and small enclosures, taken by foot measure. And

The trigon L which is also an infinite number of scales of twelfths, is of great use in measuring plans of buildings taken by feet and inch measure, which I recommend to the young student for the very best plain scale that was ever yet made publick. The excellency and use of it will be demonstrated in the several parts of this work, as they have relation thereunto.



S E C T. V.

PLATE XI.

Of plain Trigonometry.

I. Of right lined triangles.

Fig. I.

Right lined triangles are distinguished by the difference of their sides, or by the difference of their angles. As to the difference of their sides, they may be all equal, as A, which is called an equilateral triangle, or two sides may be equal and the third unequal, as B, which is called an isosceles triangle, or all the sides may be unequal as C, which is called a schalenum triangle. And these are the distinctions, in respect to their sides. The distinctions of triangles, in respect to their angles, are three also.

1. When a triangle hath one angle right, as D, 'tis called an orthogonium triangle.

2. When the triangle hath all the angles acute as A, 'tis called an oxogonium triangle.

3. When a triangle hath one angle obtuse as C or B, 'tis called an ablignium triangle. And these are the distinctions, in respect to their angles.

II. *Of trigonometrical definitions.*

Fig. I.

1. Any two sides of a triangle are termed, or called, the sides of that angle. So the sides F G and E G are the sides containing the angle F G E.

2. Every

2. Every side of a triangle is the subtending side of the angle which is opposite to it. So in the triangle F G E the side F G subtends the angle at E, and the side E F subtends the angle at G, and the side E G the angle at F. For in all plain triangles, the greatest side always subtends the greatest angle, and the lesser side the lesser angle, and equal sides equal angles.

3. The measure of an angle is an arch of a circle described upon the angular point, and is intercepted between the two sides that contain the angle. So the measure of the angle H I K is the arch *c c*. See the demonstration of problem II. sect. I. part II.

4. Every circle is divided into 360 degrees, and each degree into 60 min. See problem XXX. sect. II. part. I.

5. A quadrant is $\frac{1}{4}$ of a circle. See definition 16. sect. I. part. I.

6. The complement of an arch, less than a quadrant, is so much as an arch wanteth of 90 degrees. So the complement of the arch C L is H C.

7. The excess of an arch greater than a quadrant, is so many degrees as the arch exceedeth 90 deg.

8. A semicircle. See defi. 16. sect. I. part. I.

9. The complement of an arch, less than a semicircle, to a semicircle, is so much as the arch wanteth of 180 deg.

10. If a triangle have some of its sides equal, it is either equicrural or equilateral.

11. An equicrural triangle is that which hath two sides equal, and the third unequal.

12. An equilateral triangle. See the beginning hereof.

13. A triangle is either right angled, or oblique angled.

14. A right angled plain triangle is that which hath one right angle and two acute ones.

15. An oblique angled plain triangle is that which hath all its angles oblique, *viz.* one obtuse, and two acute.

16. In all plain triangles, the sum of all the angles are equal to a semicircle, or 180 degrees.

17. The third angle of any plain triangle is the complement of the other two, to two right angles, or 180 degrees.

III. Of the construction of such right lines as are applied to a circle, for the solution of right lined triangles.

The right lines applied to a circle for the solution, or calculation of right lined triangles, are chords, sines, tangents, half tangents, secants and versed sines, which may be projected to any assign'd radius, as follows. PLATE

PLATE XI.

Geometrically.

Fig. II.

1. A chord, or subtense, is a right line, joining the extremity of an arch. So AC is the chord of the arch AMC.
2. A line of chords, is no more than 90 deg. of the arch of any circle transfer'd from the limb to a right line.

Construction.

1. Draw the right line NV and bisect it in O, whereon, with the distance ON, describe the semicircle MNV, and on O erect the perpendicular OM, and by problem XXX. sect. II. part I. divide the semicircle into 180 deg.
2. On V place one foot of your compasses, and open the other first to 10 deg. on the semicircle, and describe the arch 10, 10, and with the opening V 20 the arch 20, 20, and the like at every degree; and thereby you'll transfer the chords from the quadrant VM, to the diameter or right line NV, which is the line of chords required.

3. A right sine is a right line drawn from the end of an arch, perpendicular to the diameter, through to the other end, or 'tis half the chord of twice the arch.

Construction.

1. From 10 deg. on the one side of the semicircle to 10 deg. on the other side, draw the right line 10 L 10, intersecting the perpendicular OM in L.
2. Perform the like operation throughout the several degrees, and thereby you will divide the line OM into the line of sines, as required.
4. A tangent is a right line perpendicular to the diameter, drawn by the extremity of the given arch, and terminated by the secant drawn from the center, thro' the extremity of the said arch.

Construction.

On the point V erect the perpendicular VY, and to it draw right lines from the center O, thro' each degree of the quadrant OMV, which lines, so drawn, shall divide the perpendicular VY into unequal parts, and shall be the tangents required.

5. A fecant is a right line drawn from the center thro' one extream of the given arch, 'till it meet with the tangent, as the fecant E 60, &c.

6. Half tangents are no other than whole tangents, numbered double, as calling 30 min. a whole $\frac{1}{2}$ tangent, and one whole tangent 2 $\frac{1}{2}$ tangents, and therefore 45 deg. of whole tangents is called 90 deg. of $\frac{1}{2}$ tangents, &c.

7. A verfed fine is a segment of the diameter, intercepted between the right fine, and the fine of 90 deg.

IV. Of divers affections incident to plain triangles.

1. A plain triangle is contained under 3 right lines, and is either right angled or oblique angled.

2. In all plain triangles two angles being given, the third is also given.

3. In the analysis of plain triangles, the angles only being given the sides cannot be found but by the reason or proportion of them. Therefore 'tis wholly requisite that one side be known.

4. In a right angle triangled two terms (besides the right angle) will suffice to find the third, so that one of them be a side.

5. In oblique angled plain triangles there must be three terms given to find a fourth.

6. In right angled plain triangles there are 7 cases, and in oblique angled plain triangles 5 cases.

V. Of axioms for the solution of the 12 cases following.

A X I O M I.

If in a right angled plain triangle, the hypotenuse be made radius, each leg will be the sine of its opposite angles, but if one leg be made radius, the hypotenuse will be the fecant, and the other leg a tangent thereunto.

A X I O M II.

In all plain triangles the sides are proportional to the sines of their opposite angles.

A X I O M III.

As the sum of the sides of any angle is to their difference; so is the tangent of half the sum of their opposite angles, to the tangent of half their difference.

A a

A X I O M

Axiom IV.

Fig. II.

As the base or longest side is to the sum of the other sides, so is the difference of those sides to the difference of the segments of the base.

VI. Of the solution of the 7 cases of right angled plain triangles.

In right angled plain triangles, I call those sides which comprehend the right angle, one the base (*viz* the longest) and the other the perpendicular, and the slope-line, or side subtending the right angle, the hypotenuse.

Case I.

PLATE VII.

The base AB 80, and the perpendicular AC 60, given to find the angle BCA.

Solution. I. Geometrically.

Fig. II.

1. Delineate BA equal to 80 equal parts of any plain scale, and on A erect the perpendicular AC, and make it equal to 60 equal parts from the same scale as you laid down BA.

2. From the extremities of the base at B, and perpendicular at C, draw the hypotenuse CB.

3. On C, with 60 degrees of a line of chords, describe the arch *aa*, and taking the quantity *an*, in your compasses, and applying it to your line of chords, you will find it to contain 53 : 00 the angle required.

2. By Trigonometrical calculation.

Analogies.

First, as the perpendicular CA 60, is to the base BA 80, so is the tangent of 45 degrees, to the tangent of 37 deg. whose complement to a quadrant, or 90 deg. is 53 deg. the angle required. Or,

Secondly, As BA 80 is to the tangent of 45 deg. so is AC 60 to the tangent of 37 deg. whose complement is 53 deg. the angle required.

Case II.

The base AB 80, and the angle BCA, 53 deg. given, to find the perpendicular AC.

Solution.

Solution. 1. Geometrically.

1. Delineate the base AB and make it equal to 80, Fig. III. and on A erect the perpendicular AD .

2. Make the arch nm , equal to the complement of the given angle, and through m draw the hypotenuse BC , which will intersect the perpendicular in C .

3. The distance CA , being laid on your scale of equal parts, will be found to be 60, which is the length required.

2. By Trigonometrical calculation.

Analogy.

As the sine of the angle BCA 53 deg. is to the base BA 80, so is the cosine, or complement, of the angle BCA 37 deg. to the perpendicular CA 60, as required.

Case III.

The hypotenuse BC 100, and the base BA 80 given, to find the angle BCA .

Solution. 1. Geometrically.

1. Make BA equal to 80, and on A erect the perpendicular AD , and on B , with the length of the hypotenuse Fig. IV. BC , describe the arch om , intersecting the perpendicular in C .

2. On C , with 60 deg. of your line of chords, describe the arch rs , and take the arch rs , and measure it on your line of chords, and it will contain 53 deg. the angle required.

2. By Trigonometrical calculation.

As the hypotenuse BC 100, is to the radius, or sine of 90 deg. so is the base BA 80, to the sine of 53 deg. the angle required.

Or thus.

As BA 80, is to BC 100, so is the radius to the sine of the complement of 53 deg. the angle required.

Case IV.

The hypotenuse BC 100, and the angle BCA 53 deg. given, to find the base.

Solution.

Solution. 1. Geometrically.

Fig. V.

1. Draw AC at pleasure, and on C, with 60 deg. of your line of chords, describe the arch *nn*, and make the angle C equal to 53 deg. the angle given, and draw the hypotenuse BC equal to 100.

2. On B, with 60 deg. of chords, describe the arch *oo*, and make the angle B equal to the complement of C, and draw BA, which shall cut CA, the perpendicular in A, and being measured on your scale of equal parts, will contain 80, the length required.

2. By Trigonometrical calculation.

As the radius, or sine of 90 deg. is to the hypotenuse BC 100, so is the sine of the angle BCA 53 deg. to the base 80, as required.

Or thus.

As the radius, or sine 90 deg. is to the sine of the angle BCA 53 deg. so is BC the hypotenuse 100, to the base 80, as required.

Case V.

The angle ABC 37 deg. and the perpendicular AC 60 given, to find the hypotenuse BC.

Solution. 1. Geometrically

Fig. VI.

1. Draw AB at pleasure, and on A erect the perpendicular AC equal to 60, and on C, with 60 deg. of chords, describe the arch *ii*, and make the angle C equal to 53 deg. the complement of the given angle, and draw the hypotenuse CiB, which will intersect the base BA, in B, and being measured on your scale of equal parts will contain 100, as required.

2. By Trigonometrical calculation.

As the sine of the angle ABC 37 deg. is to the perpendicular AC 60, so is the radius, or sine of 90 deg. to BC the hypotenuse 100, as required.

Case VI.

The hypotenuse BC 100, and the perpendicular AC 60, given, to find the base BA.

3

Solution.

Solution. I Geometrically.

1. Draw B A at pleasure, and on A erect the perpendicular A C, and make it equal to 60, and on C, with the length of the hypotenuse, describe the arch *b b*, intersecting the base in B. Fig. VII.

2. The length B A is the base required.

2. By Trigonometrical calculation.

Analogy.

As the hypotenuse B C 100, is to the radius, or sine of 90 deg. so is the perpendicular A C 60, to the sine of 37 deg. the angle A B C. Then

As the radius is to the hypotenuse 100, so is the cosine of the angle A B C 53 deg. to B A 80, the base required.

Or thus.

Multiply the perpendicular into it self as also the hypotenuse, and subtract the lesser product from the greater, then shall the square root of the remainder be the length of the base required.

Case VII.

The base B A 80, and the perpendicular A C 60 given, to find the hypotenuse.

Solution. I Geometrically.

1. Make A B equal to 80, and on A erect the perpendicular A C, equal to 60. Fig. VIII.

2. From B to C draw the hypotenuse required.

2. By Trigonometrical calculation.

Analogies.

As the perpendicular A C 60 is to the tangent of 45 deg. so is B A the base 80 to the tangent of 37 deg. the angle A B C. Then

As the cotangent of 37 deg. is to the base B A 80, so is the tangent of 45 deg. to the hypotenuse B C 100, required.

Or thus.

By theorem V. sect. III. part. I. multiply the base into its self, as also the perpendicular, and add both the products

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Of plain Trigonometry.

ducts together, then shall the square root of that sum, be the hypotenuse required.

VII. Of the solution of the 5 cases of oblique angled plain triangles.

Case I.

The sides BC 50 and CA 60 with the angle ABC 27 deg. given, to find the angle CAB .

Solution. I Geometrically.

Fig. IX.

1. Draw BA at pleasure, and make the angle ABC equal to the given angle, and make BC equal to 50.

2. On C , with the distance of CA 60, describe the arch tt , intersecting the base in A , whereon, with 60 deg. of chords, describe the arch am , which being measured on the line of chords, will be equal to 22 deg. 30 min. the angle required.

2. By Trigonometrical calculation.

Analogies. By axiom II.

As the side CA 60, is to the sine of the angle ABC , 27 deg. so is the side BC 50, to the sine of 22 deg. 30 min. the angle required.

Or thus.

As the side BC 50, is to the side CA 60, so is the sine of 27 deg. the angle ABC , to 22 deg. 30 min. the angle required.

Case II.

The sides BC 50, and CA 60, with the angle ACB 131 deg. 30 min. given, to find the other angles CAB and ABC .

Solution. I. Geometrically.

Fig. X

1. Delineate BC and CA , making the angle C equal to the given angle.

2. Join AB the base, and with 60 deg. of the line of chords on the points A and B , describe the arches op and qr , which being severally measured on the line of chords, will be the quantity of the angles required.

2. By Trigonometrical calculation.

Analogie. By axiom III.

As the sum of the sides BC and CA 100, is to their difference,

difference, viz. 10. so is the tangent of $\frac{1}{2}$ the opposite angles 24 deg. 45 min. to the tangent of $\frac{1}{2}$ their difference, viz. 2 deg. 45 min. Then

This $\frac{1}{2}$ difference subtracted from the $\frac{1}{2}$ sum of the opposite angles gives the inferior angle; but added to the $\frac{1}{2}$ sum of the opposite angles gives the superior angle.

Or thus.

As the $\frac{1}{2}$ sum of the given sides is to their $\frac{1}{2}$ difference, so is the tangent of $\frac{1}{2}$ the opposite angles to the tangent of $\frac{1}{2}$ their difference.

Then add and subtract as before directed.

Case III.

The angle A B C and C A B, with the side B C 50, opposite to the angle C A B given, to find the side or base A C.

Solution. 1. Geometrically.

Fig. XI.

1. Make B C equal to 50, and make the angle C B A equal to 131 deg. 30 min. as given, and draw B A infinitely.

2. Make the angle B C A equal to the complement of the two given angles, to 180 deg and draw A C, which will intersect B A in A.

3. The line A C is the base required, and if measured on your plain scale, will be equal to 100 of those parts, as B C contains 50.

2. By Trigonometrical calculation.

Analogy. By axiom II.

As the sine of the angle C A B 27 deg. is to the side B C 50, so is the sine complement of the angle A B C, viz. 49 deg. to 30 min. the base 100.

Case IV.

The sides B C 60, and C A 100, with the angle C 22 deg. 30 min. comprehended by them given, to find the side A B.

Solution. 1. Geometrically.

Fig. XII.

1. Make A C, B C, and the angle C, equal to the measures given, and from their extrems draw A B, and it shall be the side required.

2. By

2. By Trigonometrical calculation.

1. Find the angle at A, by axiom I. or II. then the analogy is thus, as the sine of the angle C A B is to B C; so is the sine of the angle A C B to the side AB, required.

Cafe V.

The 3 sides AC 100, A B 50, B C 60, given, to find the angle B C A, or the angle C A B.

Solution. 1. Geometrically.

Fig. XIII.

1. By problem XIV. sect. II. part I. delineate the triangle A B C equal to the 3 given sides.

2. With 60 deg. of chords on A and C, describe the arches *nn* and *rr*, which being measured on the line of chords, will shew the quantity of each angle as required.

2. By Trigonometrical calculation.

For the solution of this cafe, two operations are required, *viz.* the first, to find the segment of the base A D and D C, and the second to find the angles required.


Analogy. First by axiom IV.

As the sum of the base A C 100, is to the sides A B and B C 110, so is the difference of A B and B C, (*viz.* 10) to the difference of the segments of the base (*viz.* 14.) This segment added to the base, *viz.* 100, the sum is 114, whose $\frac{1}{2}$, *viz.* 57, is the superiour segment D C, which being subtracted from A C 100, leaves A D 43 the lesser segment. And now there are constituted two right angled plain triangles, by which the angles may thus be found, by this analogy of cafe III. of right angled plain triangles.

Analogy.

As the hypotenuse B C 60, is to the radius, or sine of 90 deg. so is the greater segment D C 57, to the angle D B C, whose complement to 90 deg. is the angle B C A, required.

Again,

As the hypotenuse B C 60, is to the radius, so is the lesser segment A D 43, to the angle D B A, whose complement to 90 deg. is the angle B A C, required. 

✧ I advise that the young student be perfect in these 12 cases, before he proceed any further. For hereon depend not only the principles of framing all kinds of roofs of buildings, measuring all kinds of heights and distances, accessible, or inaccessible, surveying of land, measuring, &c. but also of navigation, fortification, and gunnery, which some youths may delight in the study of, besides the subjects hereof, they being both profitable and delightful.

S E C T. VI.

Of the Geometrical Construction of Draughts, Plans, and Maps of Lands, Gardens, Farms, Buildings, &c.

TO enumerate the many mathematical instruments invented for this purpose, and to describe their use would be but a needless amusing work, seeing that herein the only instruments that I make use of are the common *Gunter's* chain, and a common five and ten foot rod, divided into feet and inches, &c. with which I shall shew how to describe any plan, with much less trouble and in much less time than by the help of any theodolite, plain table, circumferentor, &c. and, if I mistake not, far more exact.

When the measure of any length is taken by a chain, and contains 10 chains 73 links, 'tis thus written 10 : 73, so also is 73 chains 4 links, thus 73 : 04; and when any length is measured that is less than a chain's length, as 73 links, 'tis either written thus 00 : 73, or thus : . 73, with a period or full stop before it, in the same manner, as a decimal fraction.

✧ The reason why the links are often times express'd according to the last way, is, because in taking the measures of offsets, (which are very often under the length of a chain) there is no room to express them according to the former way, between the offsets taken. See the measures of the offsets taken from the line LK, fig. XXI. plate XI. where may be seen, at one view, a demonstration thereof.

C c

The

The appurtenances belonging to the chain are ten small rods, each about two foot in length, shod and sharp-pointed with iron, to stick in the ground at the end of every chain's length, when a length is measuring.

The manner of measuring a length is as follows.

1. One man takes an end of the chain in his hand, and walks towards the place he is to measure to, taking with him, under his arm, the aforesaid ten sticks.
2. When he has walk'd the length of the chain, the hindermost man causes him to move either to the right hand or to the left, &c. 'till he has placed him in a right line position from him, to the place to which they measure. Which being done, and the chain laid very streight and tight, the foremost man sticks down one of his sticks and leaves it, and then walks on forward towards the mark he measures to, 'till the hindermost man comes up to the stick, the first stick'd down. And then (as aforesaid) the hindermost man directs the foremost in a right line with the mark. Where after laying the chain streight, he sticks down a second stick, and then walks forward towards the mark, and the person behind, also, bringing those sticks with him, as he takes them up at the end of every chain, 'till he comes to the next, and there repeats the same again, &c. and thereby he knows what number of chains is contain'd in that length so measured.

PROBLEM I.

PLATE XI.

Let it be required to make a plan of the field BDE FGHIKL, fig. XXI. plate XI.

1. Walk round the bounds of the same, and at every sudden turn erect a stick, or staff, of about five foot high, with a piece of white paper on the top of each, as at the several turns B, D, E, F, G, H, I, K, L.
2. Go into some convenient part of the field, from which you may see all the station staffs before erected, as at A, and there drive down a small stake.
3. Measure from A to any one of the station staffs, as to L, and note down the chains and links contain'd therein, and also measure from L to K, and from K to A, and then you have the lengths of the three sides of the triangle ALK, given.
4. By problem XIV. sect. I. part I. make (or describe) the triangle ALK, whose three sides shall be equal to the aforesaid three lines measured.

5. Measure and delineate the several offsets $m o, m o, &c.$ by problem VI. sect. I. part II. and describe the crooked line L, o, o, o, o, o, K .

6. Measure from the station staff at K to I , and also from I to A , and then supposing $A K$ to be a third given line, by problem XIV. sect. I. part I. describe the triangle $A K I$, and from the line $K I$ fet off the several offsets $m r, m r, &c.$ as aforesaid, and delineate the crooked line $K r r r, &c.$ I. Fig. XXI

7. Measure from the station staff at I , to the next at H , and measure the distance $I H$, and from H to A , and supposing the line $A I$ to be a third line, by problem XIV. sect. I. part I. delineate the lines $I H$ and $H A$, and by problem VI. sect. I. part II. measure and fet off the several offsets $m s, m s, m s, &c.$ and trace the crooked line $I s s s, &c.$ H .

8. Proceed in the very same manner from H to G , and from thence to F, E, D, B and L , and thereby you will, with great ease, exactly describe the plan, or figure of the field, as required.

☞ When you have several fields to survey, then you must know how to place your station in the second field, after you have completed the first, which is to be performed as follows.

1. Go into the second field, fig. XXII. and place your station staffs in convenient places about the same, as at N, O, P, Q, U, R, T and V .

2. In a convenient place, as at M , fix your station as you did in the former field at A .

3. Measure from A to M and fet down the measure, and also measure from L to M , and note that also. And then you have the length of two given lines. And if you suppose $A L$ to be the third, then by problem XIV. sect. I. part I. describe the lines $A M$ and $L M$, intersecting each other in the point M , from which you may measure to every station staff, &c. and form that field, in the very same manner as the first, and the like rule from thence to X , fig. XXIII. and from that to others, &c.

N. B. When any inclosure is so situated, that you cannot go within side to make a plan thereof, as in the preceding, then you must go round the same without-side, and describe the plan thereof as following.

1. Make

Of the Geometrical Construction of Draughts, &c.

1. Make an eye-draught thereof (which is a rough draught on paper) wherein describe every individual angle turning, &c.

2. Standing at any part thereof, as at m , conceive the line mAB , and from it measure the several offsets l, l, l , &c. and at their extreams draw the side of the field FED , &c. according to problem VI. sect. I. part II.

3. Standing at m , conceive the line $mg h$, and by prob. V. sect. I. part II. measure the angle m , and note it down, and afterwards take the several offsets o, o, o , &c. as before, and then place yourself in another convenient place, as at $g h$, and there conceive the line $h i, g h$, and then proceed as before, and so from thence to other stations, till you have taken the whole circumference of the field; after which delineate the same from the eye-draught, by the rules before laid down, and thereby you will have an exact plan, as required, notwithstanding you were not admitted within the same; which oftentimes happens by wood, water, &c. or when the land is a person's who will not allow a surveyor to go thereon.

If you conceive the aforesaid figure (or at least the circumference thereof) to be the side of so many streets as incloses that quantity of ground, you may, by the very same rule, delineate any parish, town, city, &c. provided that as you go on, you measure the offsets to the right hand side of the street as well as to the left, as the offsets mr, mr , &c. in the figure, and by their extreams describe that side of the street, &c. also. But when the sides of streets are streight lines, then there need none of these offsets, and the work is performed with much less trouble, and therefore I made choice of this most difficult part for an example.

PROBLEM II.

PLATE XII.

To make a plan or draught of any garden, wilderness, &c. and beautify the same with proper colours.

Let $IKLM$ be a garden divided into walks, parterres, borders, &c. and 'tis required to draw a draught of the same, and to distinguish each particular with proper colours.

1. Draw the central line ON .

2. Measure the breadth of the middle walk B , and at the parallel distance of $\frac{1}{2} BC$, draw the lines BF and CG , infinitely.

3. On



3. On any point of the central line as at O, draw the line P Q, at right angles infinitely, and at the parallel distance of P V (the breadth of the terrace) draw the line V K infinitely.

4. At the parallel distance of V O, draw the line O P, and divide that parallel distance with two other parallel lines in such proportion as the slope and verges are divided.

5. At the distance of O A draw A D infinitely, as also the line E H at the parallel distance of A E, and likewise the lines XX and YY, at such distances as their breadths contain. And thus have you, by those parallel lines, divided the several cross walks, &c. therein, in respect to their breadths. And to find their terminations, or intersections, proceed as follows.

1. On the lines A D and E H, from the points B C and F G, set off the measures B A, C D, E F, G H, and draw the lines A E and H D. Fig. XXIV.

2. The two parterres being thus enclosed, and their several parts being all parallel to each other, therefore measure the distances between the several lines contained therein, and draw every particular line parallel to the central line N O.

3. Give to every right line its particular length, and describe every circular line by the rules laid down in sect. II. part. I. and thereby you will complete the several parts therein contained. And as the other outer walks, slopes, verges, &c. are all parallel to the aforesaid, therefore at those parallel distances, describe every line, and thereby you will complete the whole draught, as required. And what is said of the delineation of this, the same is to be understood of all others of the like nature. And, indeed, he that is well acquainted with all the preceding problems, is enabled to make a plan of this or any other garden without any more directions. And therefore it being needless to treat any further thereon, I shall leave the ingenious student to the practice thereof. And for his exercise I have subjoin'd the plan of a wilderness, fig. XXV plate XIII. wherein are contain'd some few artificial lines, that may be worthy of his consideration, and not a small help to invention in designing gardens after that rural manner; which are not entirely new, but far preferable to the most regular set forms hitherto practis'd (as I observ'd before) in most parts of *England*, to the great disadvantage of the proprietors, and shame of the pretended performers. And to demonstrate more plainly, that the laying out of gardens has no sort of recourse to the exterior figure, or

bounds thereof, being regular, I have subjoined the plan, fig. XXVI. plate XII. wherein is delineated an artinatural walk, which demonstrates that the most beautiful gardens are to be made in the most irregular forms or boundaries. Altho' the practice hitherto has been the reverse. And thereby oftentimes to make a garden regular (*or rather totally ruin it*) the gentleman has been advised to purchase a part of his neighbours land at a very dear rate, purely for the sake of regularity, which in all gardens should be avoided, as may be seen in plate XIV. which is an entire garden according to the truth of designing, wherein you may behold art and nature in conjunction with each other, which in gardening is a general axiom to be observed, &c.

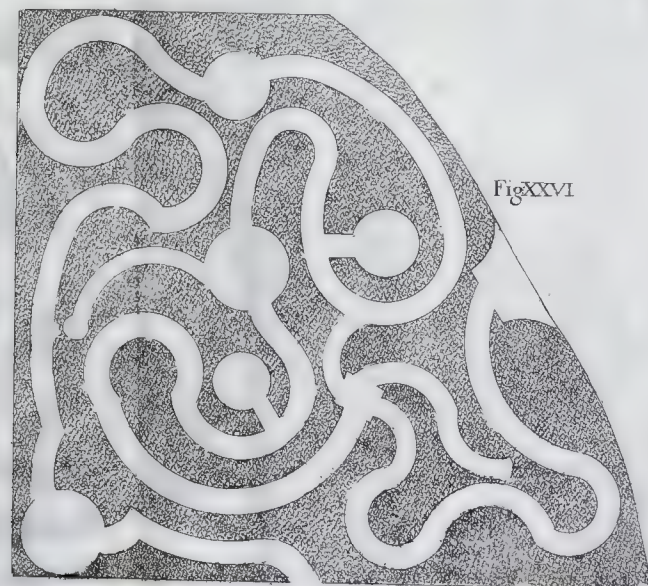
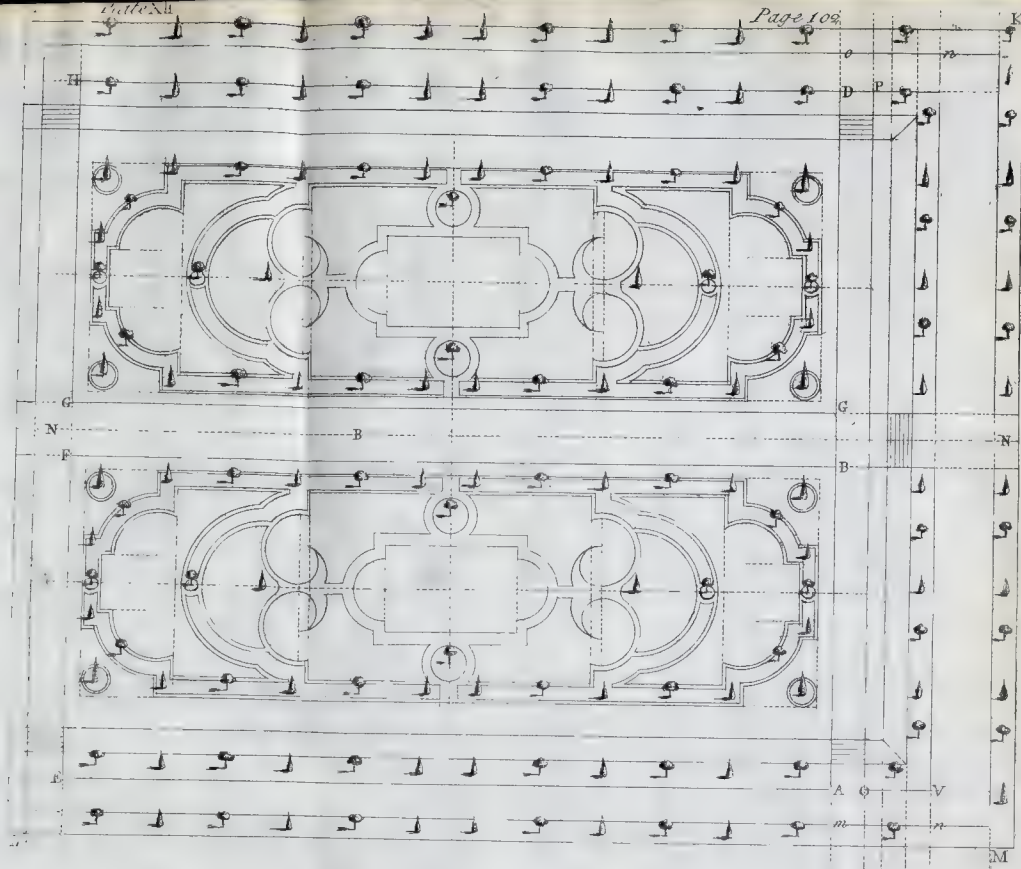
N B. To represent grass you must use sap-green, and gumbouge lightn'd for sand or gravel.

PROBLEM III.

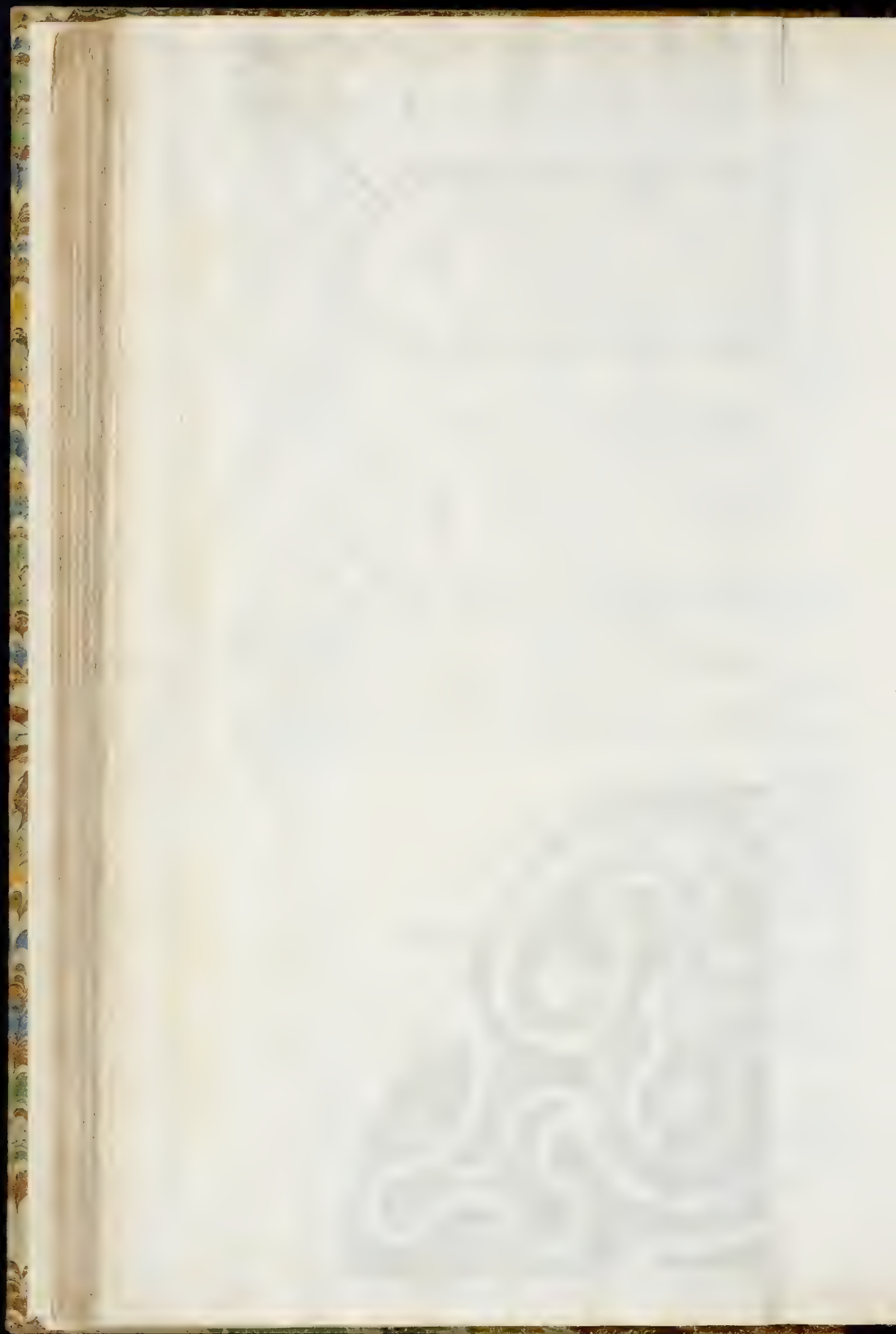
PLATE XV.

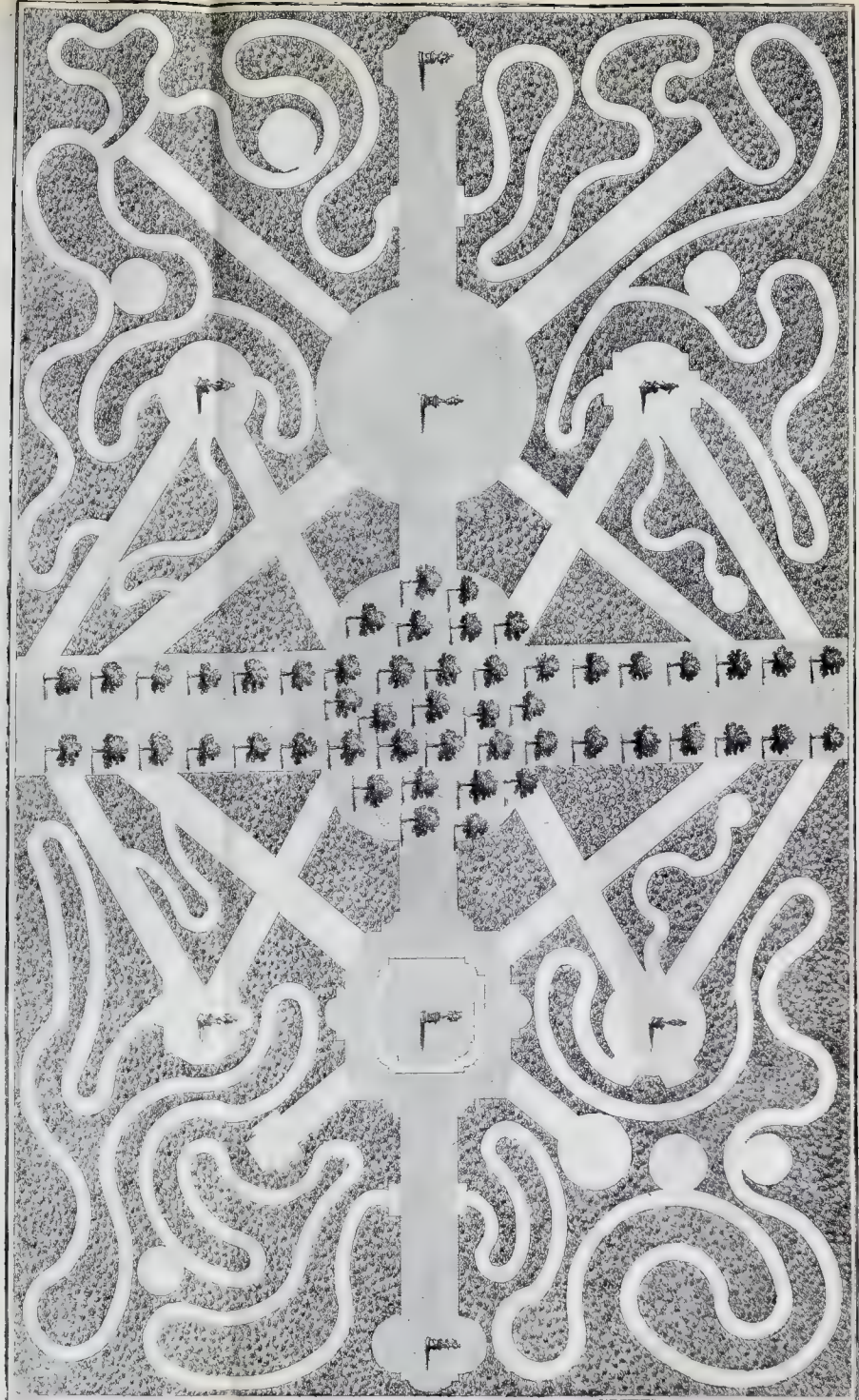
How to make the map of any estate, farm, lordship, mannor, &c. Let it be required to make a map of the lands, fig. XXVII.

1. By problem 7. sect. I. part II. make a plan of the dwelling house B, and stable A.
2. By problem 5. sect. I. part II. take the quantity of Fig. XXVII. the angle F, and draw the line F G.
3. Also take the quantity of the angle G, and draw the line G, e, equal to the measure taken, and by problem VII. sect. I. part II. make the plan of the barn D and the stable E.
4. Take the angle H, and draw H I equal to its measure.
5. Take the angle I, and draw I N equal to its measure.
6. Measure the lines I, o, o, o, and o, N, and complete the trapezium I, o, o, N. So will o, o, be one end of the barn D E.
7. Measure either or both of the angles, o, and o, and complete the oblong plan of the barn D E, and also by the same rule complete the barn D I.
8. Measure the lines N K and L K, and delineate them. So shall you have completed the house, barns, stables, yards, &c.
9. In the field Z, in any convenient part, as at Z, drive down a stake for a station.
10. Measure the lines V Z and T Z, and delineate them by the latter part of problem I. hereof.
11. Your



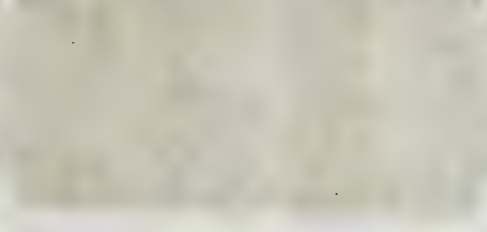
FigXXVI





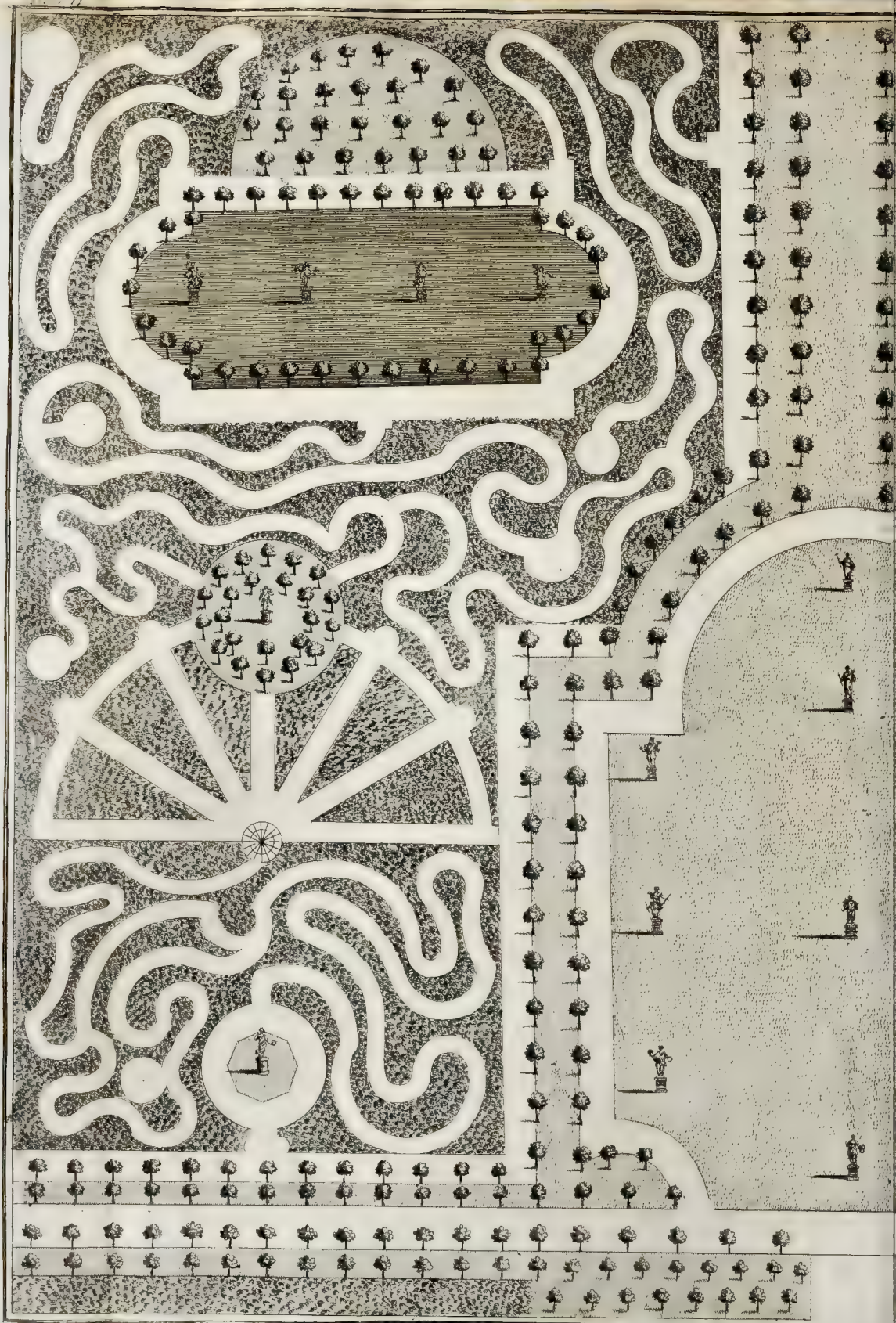


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II. Your station point being thus placed, measure from thence into every angle, or to such sudden turns in the hedges, as are remarkable, and then proceed in all respects as is laid down in problem I. hereof, and thereby you will exactly delineate a true map of the farm, as required.

Advertisment.

I do hereby advise every gentleman, that when they employ a land surveyor to measure and map an estate, they cause him to describe every timber tree contain'd therein, and that the timber of every tree be measured, and the quantity of that measure written underneath each particular tree, with the first letter of the tree's name, as an E for elm, an O for oak, an A for ash, &c. and thereby the true value of an estate, both of land and timber, may be known at all times, without any sort of trouble. Also if a gentleman lets any land by lease, or otherwise, 'tis not in the power of his tenant to wrong him of any one tree of timber, contained in the lands to him demised, and many other excellent advantages too tedious here to mention.

Note, That when timber-trees stand so very thick (as in a wood) that the representation of every tree, with its measure, cannot be inserted, then at all such times the surveyor must represent the basis of every tree, by a point or period, with numerical figures to each, as 1, 2, 3, 4, 5, &c. Which numbers refer you to the very same numbers in a column placed on one side of the map, against which stands the true solid content of every tree, as each point, or figure represents. See LM of *Nuns wood*, with its tables of quantities, &c.

PROBLEM IV.

PLATE XVI.

How to increase or decrease any draught, at pleasure.

Let *a b c d e f g h i k l m n o p*, &c. be a small map of a farm, and 'tis required to increase the same four times its magnitude.

1. In any part of the same, as at A, make a point, and from that point, through all the several angles, draw right lines, and continue them infinitely.

2. Open your compasses from A, the given point, to *b*, and on the same line set that distance from *b* to B.

4

3. Make

Fig.
XXVIII.

3. Make Cc equal to Aa , and draw the line BC .
4. Make Dd equal to Aa , and draw the line CD , and in the same manner, proceed 'till you have pass'd through the whole, and thereby you'll encrease the map, as required.

Note, That by doubling the distance from the given point A to the several angles, you thereby (as afore-said) encrease the figure four times; therefore the double of that is eight times, and its half but two times, and consequently its quarter but once. So that from these proportions you may increase, or decrease, any map to any proportion, as may be required.

PROBLEM V.

PLATE XVI.

How to describe (and account for) the diminution of the breadths of long walks, avenues, vistas, &c.

'Tis observable, that the breadth of long walks, avenues, &c. appears to be much narrower at the further end, than at that end where the person stands, notwithstanding the sides of the walk are actually parallel to each other. But what is the reason thereof, no gardener, or indeed any other, has yet accounted for it to the publick. It is occasion'd as follows,

1. All objects that appear equal in height, or breadth, are seen under equal angles; but when objects appear unequal, and are equal, such objects are seen under unequal angles.

Demonstration.

1. Let the lines CEG and ADF , represent the hedge lines of a walk, &c.

2. Draw the central line BZ , and let the points C, E, G, F, D, A , be remarkable places in the hedge lines CEG and FDA , and let the line WXV be drawn at right angles to ZB , as also the lines DE and AC .

3. Make TB equal to TX , and draw the lines CB and AB , as also WT and VT , as also EB and DB , and GB and FB .

4. The objects CA and VW , being equal to each other, and they lying placed at equal distances therefrom, as at T and B , are seen under equal angles, and do appear to be equal to each other; but the objects DE and FG , appear both less than VW or AC , by reason the angle EBD and

Fig. XXX.

*The Lands of St. Mary's Abbey
situated on the Parish of T.
in the County of S.
Surveyed and mapped
By
B.L.*

Table of Contents

	Acres	Roods	Poles
A Broom Field	4	2	9
C Castle Plat	2	0	27
D Swamp Close	4	3	29
E Fern Field	7	2	11
F Fern Close	3	0	7
G Well Close	4	3	15
H Marsh mead	3	1	15
I Lime cove	3	1	7
J Fern Close	6	1	20
K Fern Close	3	2	9
L Fern Close	3	2	37
M Fern Close	5	3	31
N Home Close	2	1	20
O Heale Land &c.	1	3	10
P Water Close	4	0	7
Q Sheep Pasture	3	1	21
R Bush Close	4	2	11
S Rock mead	4	1	2
T Run high Field	3	4	10
V Run high Field	3	3	3
W Run high Field	3	3	3
X Run high Field	3	3	3
Y Run high Field	3	3	3
Z Run high Field	3	3	3
Sum Total	11	25	57

Quantity of Timber in *Acres*
WOOD.

	L	E	L	E	L	E	L	E	L	E
1	1	0	1	0	1	0	1	0	1	0
2	1	0	1	0	1	0	1	0	1	0
3	1	0	1	0	1	0	1	0	1	0
4	1	0	1	0	1	0	1	0	1	0
5	1	0	1	0	1	0	1	0	1	0
6	1	0	1	0	1	0	1	0	1	0
7	1	0	1	0	1	0	1	0	1	0
8	1	0	1	0	1	0	1	0	1	0
9	1	0	1	0	1	0	1	0	1	0



PROBLEM VII.

How to give the exact height to any statue placed on a building, that the same shall appear equal to the common height of a man standing on the ground.

Let DC be the common height of a man (as five foot nine, or ten inches) and 'tis required to place a statue on the building at I, shall that appear equal in height thereunto.

- I. At any convenient place, as at A, upon the level of the building, place your station, and draw the lines AC, AD and AI.
1. XXXII. 2. On the point A, with any distance, describe the arch BEFG, and make FG equal to EB, and draw the line AGH.
3. Continue CI to H, so shall IH be the height of the object, required.

Demonstration.

The angle EAB is equal to GAF, therefore since HI is seen under the very same angle, as DC, by problem V. hereof, HI is in appearance equal to DC, and is the true height of that object, which is what was to be demonstrated.





T H E
P R A C T I C E
O F

*Architecture, Gardening, Mensuration, and
Land-Surveying, Geometrically demonstrated.*

P A R T III.

Of Geometrical Axioms and Analogies, for the
Mensuration of all Kind of Lines, superficial
Figures, and solid Bodies, &c.

*Since the Mensuration of all Kind of Work is
for the Generality perform'd by Crofs Multiplication,
therefore I will first explain the same, and after-
wards proceed to Mensuration in general.*

S E C T. I.

Of Crofs Multiplication.

LET it be required to multiply seven feet, three inches, six parts, by five feet, four inches, six parts.

3

Place

	feet.inch.part.
Place the numbers thus	$\begin{array}{r} 7 : 3 : 6 \\ 5 : 4 : 6 \end{array}$
1. Multiply 5 feet by 7, and the product is	35 : 0 : 0
2. Multiply the feet into the inches, as 5 into 3, which is 15, 12 of which make one foot, which place under the feet, and the remaining 3 under the inches.	1 : 3 : 0
3. Multiply the 7 feet into 4 inches, and the product is 28, wherein is twice 12, and 4 remaining, which is 2 feet and 4 inches, which place under feet and inches.	2 : 4 : 0
4. Multiply the inches into themselves and their product is 12, which is 1 inch, which place under inches.	0 : 1 : 0
5. Multiply the parts into the feet, as 6 times 7 is 42, wherein 12 is contain'd thrice, and 6 remaining, which is 3 inches and 6 parts, which write under inches and parts.	0 : 3 : 6
6. Multiply the 6 parts into the 5 feet, and the product is 30, or 2 inches $\frac{1}{2}$, which also write down.	0 : 2 : 6
7. Multiply the parts into the inches, as 6 into 3, and the sum is 18 parts, or 1 part and $\frac{1}{2}$, which write down under parts, as thus.	0 : 0 : 1 $\frac{1}{2}$
8. Multiply the 6 into 4, and the product is 24, or 2 parts, which also place under parts, thus.	0 : 0 : 2
Lastly, Multiply the parts into themselves, and their product is 36, of which 144 make 1 part, therefore 36 is	0 : 0 : 0 $\frac{1}{4}$

And the sum is $\underline{\underline{39 : 2 : 3 \frac{3}{4}}}$

SECT. II.

Of Geometrical Axioms for the Mensuration of Lines and Superficial Figures.

PLATE XVII.

PROBLEM I.

To measure the geometrical square ABCD, whose sides are each equal to 16 foot 6 inches.

Rule.

Multiply any one side, as AB, 16 foot 6 inches, by any other of the sides, as BD, and the product will be 272 foot 36 inches, the superficial content required. Fig. I.

PROBLEM II.

To measure the parallelogram ABCD, whose longest side is equal to 28 foot 9 inches, and its shortest to 6 foot 6 inches.

Rule.

Multiply the length 28 foot 9 inches, by the breadth 6 foot 6 inches, and the product is 186 $\frac{12}{14}$ the superficial content required. Fig. II.

PROBLEM III.

To measure the triangle NMO, whose longest side NO is equal to 42 foot, and the perpendicular MA to 16 foot.

☞ That before any right lined triangle is measured, a perpendicular line is let fall upon the longest side (or base) from the opposite angle.

Rule.

Multiply half the perpendicular (*viz.* 8.) by 42, the length of the base NO, and the product 336 is the superficial content required. Fig. III.

PROBLEM IV.

To measure the trapezium OMNV.

F f Rule.

Rule.

Fig. IV.

1. Draw the line MV, and then the trapezium is divided into two triangles.
2. Measure each triangle severally, and the sums together, and the total will be the superficial content required.

PROBLEM V.

To measure any irregular figure, as the figure L, O, V, R, S, N, M, I, D, E, W.

Rule.

Fig. V.

1. Divide the figure into triangles, and measure each triangle severally, and note its quantity.
2. Add all the triangles together, and the total will be the superficial content of the figure required.

PROBLEM VI.

To measure any regular polygon, as a pentagon, hexagon, heptagon, octagon, nonagon, or decagon.

For the mensuration of all those regular polygons, there is one general rule, viz.

Fig. VI.

Multiply half the circumference, as E, O, M, I, by the radius or semidiameter AN, and the product will be equal to the superficial content required. Or otherwise, you may divide the figure into triangles, and then measure each triangle, and add up the sum total of the whole, and that shall be the superficial content required.

PROBLEM VII.

The side of a pentagon, &c. as BA given, to find the semidiameter of a circle inscribed therein.

Rule.

Fig. XV.

As 182 is to 125, so is the side of the polygon (be it any whatsoever) to the radius of the circle inscribed therein.

PROBLEM VIII.

To measure any circle, or section of a circle.

☞ The diameter of every circle hath such proportion to its own circumference, as 7 hath to 22, or rather as 113 is to 355, therefore if any one be given, the other may thus be found.

Rule

Rule I.

The diameter being given, to find the circumference.

Practice.

Multiply the diameter given by 22, and the product divide by 7, the quotient is the circumference required.

Rule II.

The circumference being given, to find the diameter.

Practice.

Multiply the circumference given by 7, and divide the product by 22, and the quotient is the diameter required.

Rule III.

The diameter of a circle being given, to find the area.

Practice.

1. Multiply the diameter into itself, and that product multiply by 11.

2. Divide the last product by 14, and the quotient is the area required.

Rule IV.

The circumference of a circle being given, to find the area.

Practice.

1. Multiply the circumference given, by itself, and the product also multiply by 7.

2. Divide the last product by 88, and the quotient will be the area required.

Rule V.

The circumference and diameter of a circle being given, to find the area.

Practice.

Multiply half the circumference by half the diameter, and the product will be the area required.

Rule VI.

The area of any circle being given, to find the diameter.

Practice.

Divide the area given by 11, and the quotient is the diameter required.

Or thus.

As 22, is to 28, so is the area to the diameter required.

Rule. VII.

The area of any circle being given, to find its circumference.

Practice.

As 7 is to 88, so is the area to the square of the circumference, whose root is the circumference required.

Rule VIII.

The area of any circle being given, to find the side of a square equal thereunto.

Practice.

Extract the square root of the area given, and the root shall be the side of the square required.

Rule IX.

The diameter of any circle being given, to find the side of a square, the content of which square shall be equal to the superficial content of the circle, whose diameter was given.

Practice.

As 7 is to 22, so is the square of the radius to the area required.

Or thus.

As 113 is to 355, so is the square of the radius to the area required.

Rule X.

The diameter and curve line of a semicircle being given, to find the content.

Practice.

Multiply $\frac{\pi}{2}$ the curve by the radius, and the product is the content required.

Rule

Rule XI.

The radius and curve line of a sector of a circle being given, to find the content.

Practice.

Multiply the radius by $\frac{1}{2}$ the curve line, and the product is the content required.

Rule XII.

Any part, or segment, of a circle being given, as B C D L, fig. XVIII. to find the area thereof.

Practice.

1. By problem XI. sect. II. part I. find the center E of the arch B C D, and draw the lines B E and D E, which will complete the quadrant E B C D.

2. By the last rule, measure the whole sector E B D, and from it deduct the triangle E B D, and the remainder is the content of the segment required.

PROBLEM IX.

To measure any ellipsis or oval form.

Rule.

Multiply the longest diameter by the shortest, and extract the square root of the product, which square root shall be the diameter of a circle equal to the ellipsis, which being given, you may by the preceding problem find the area required.

PROBLEM X.

To measure the superficies of a sphere, or hemisphere.

Rule.

The superficies of a sphere is equal to four great circles of that sphere, therefore find the area of a circle, whose diameter is equal to the diameter of the sphere given, and four times that area is the area of the sphere required, and consequently the half is the area of the hemisphere also.

G g

Or

Or thus,

Multiply the diameter by the circumference, and the product shall be the superficial content of the sphere or globe. And if the axis only is given, the superficial content may thus be found, *viz.* as 7 is to 22, so is the square of the diameter to the content required.

PROBLEM XI.

To measure the superficial content of any cone.

Practice.

1. Find the superficial content of the base by problem VIII. hereof.

2. Multiply the length contained between the vertex and the circumference of the base, by $\frac{1}{2}$ the circumference of the base, and to the product add the content of the base, and the total is the content required.

PROBLEM XII.

To measure the superficial content of any pyramis.

1. By the definition 33. sect. I. part I. a pyramis is comprehended under divers flat superficies, whose areas being found by the preceding problems and added together, their total will be the content required.

PROBLEM XIII.

To find the superficial content of a cylinder.

Practice.

1. Find the area of both ends by problem VIII. hereof, as also its circumference, which multiplied into the length, and the product added to the areas of both ends, their total is the content required.

PROBLEM XIV.

To measure the superficial content of any fragment or part of a globe, or sphere.

Practice.

As the whole diameter of the globe is to the superficial content of the globe, so is that part of the diameter belonging to the part, or fragment of the globe, to the superficial content required.

SECT.

SECT. III.

PLATE XVII.

Of Geometrical Axioms for the Mensuration of Solid Bodies.

PROBLEM I.

To measure the solidity of a cube, as the cube ABCD, whose side is equal to 3 foot.

Proportion.

As 1 is to 3 the breadth, so is 3 to 9, and 9 to 27, the solidity required.

Or thus,

1. Multiply the side 3 by 3, the product is 9.
2. Multiply the last product 9 by 3 the depth, and the product will be 27, the solidity required.

¶ 'Tis to be observed that a parallelopipedon is but a long cube, and that the above rules, or proportions will measure the same, therefore an example is needless. See fig. X.

Fig. IX.

PROBLEM II.

To measure a pyramis, as the pyramis MAON, whose base is a geometrical square, having each of its sides equal to 6, and its altitude to 12 foot.

Rule.

1. Find the area of the base.
2. Multiply the area by $\frac{1}{3}$ of the altitude, and the product will be the solidity required. And as this is the rule by which a cone is also measured (as the cone, fig. XII.) therefore 'tis needless to add an example.

Fig. XI.

PROBLEM

PROBLEM III.

To measure the frustum of a cone, or pyramis, as the frustum A and B, in figures XIII, and XIV.

Rule.

1. Find the area of each end of the frustum.
2. Multiply one area by the other, and extract the square root of their product.
3. Add this square root to the sum of both areas, and their sum multiply by $\frac{1}{3}$ of the frustum's length, and that product shall be the true solidity required.

¶ If you find the areas in inches, you must divide the solidity so found, by 1728, the number of cubical inches in a cubical foot, and the quotient will be the content in feet.

¶ I do advise the young student to be perfect in this problem, for hereon depends the whole truth of timber measuring, which hitherto has been kept in the dark, to the great injury of all gentlemen, who have disposed of great quantities of timber according to the customary (tho' false and base) way of measuring.

PROBLEM IV.

To measure the solidity of a sphere, globe, or ball.

Suppose the diameter of a sphere, globe, &c. be 12 inches, what is the solidity thereof?

Proportion.

As 21 is to 11, so is the cube of the diameter to the solidity required.

Or thus.

Cube the diameter, multiply by 11, and divide by 21. See the operation.

Diameter

Diameter	12	
	12	
	<hr/>	
Product	144	
	12	
	<hr/>	
	288	
	144	
	<hr/>	
	1728	The diameter cubed.
Multiply by	11	
	<hr/>	
	1728	
	<hr/>	
	1728	
Divide by	21	
	$\overline{)19008(905, \text{ solidity required.}}$	
	$\underline{189}$	
	108	
	$\underline{105}$	
	3	$\frac{3}{21}$ remains.

PROBLEM V.

The solidity of a sphere being given, to find its diameter or axis.

Practice.

As 22 is to 42, so is the solidity to the axis or diameter required.

PROBLEM VI.

A segment or portion of a sphere being given, to find its axis.

Practice.

1. Multiply $\frac{1}{2}$ the chord of the segment, and divide the product by the height of the segment.

2. For the quotient add the height of the given portion, and the sum is the axis required.

PROBLEM VII.

To measure the solidity of a cylinder.

Rule

1. Find the superficial content of one end.

2. Multiply the area so found by the length, and the product is the content required.

H h

PROBLEM

PROBLEM VIII.

To measure the solidity of a prism.

1. Find the superficial content of one end.
2. Multiply the content so found, by the length, and the product is the solidity required.

Problem IX.

To measure the solidity of a mount, terrace walk, canal, &c.

Let A B C D E F represent the profile of a mount, terrace walk, &c. and 'tis required to measure the solidity thereof.

Rule.

1. The slopes A B E and C D F, are prisms, therefore measure those parts according to the last problem.
2. The body, or midft B C E F, is a long cube. Therefore measure that part according to problem I. hereof.
3. Add both their quantities together, and the total shall be the solidity required.

Fig. XVI.

☞ This kind of measure is always measured by the cubical yard (which by gardeners is called a load) and contains 27 cubical feet. Therefore if the dimensions be taken in feet, the solidity must be divided by 27, and the quotient will be the solidity in yards.

The profile fig. XVII. is a representation of the inside of a canal, fish-pond, &c. and is measured by the very same rule as the above. Therefore to repeat the same again is needless.

These three last sections being duly consider'd, and well understood (which may soon be done) the young student will thereby be enabled to measure the superficial or solid content of any figure or body whatsoever. And seeing that the most difficult part of the mensuration of building, land, &c. consists in the manner of taking the dimensions, therefore that shall be the work of the next section, to which I proceed.

S E C T.

S E C T. IV.

Of the several Measures that Artificers work is accounted by, and the Manner of taking their Dimensions.

I. Of Carpenters work.

1. **T**H E principal work of carpenters is flooring, partitioning, and roofing, all which are measured by the square, or 100 feet produced by 10 feet squared or multiplied into itself.

2. When you are to take the dimensions of the frame of any timber floor, you must allow for the length of the joist laid in the walls, which is generally 9 or 10 inches.

3. When you measure flooring, without joist, the dimensions are to be taken to the extrems thereof, out of which you must deduct the well-holes of the stair-case, and the chimney ways.

4. When you measure partitioning, you must deduct doors and door-cases, and windows also, provided they are not to be included.

5. When you measure roofs, measure the length of the rafters by the length of the roof, and afterwards the hypps singly (instead of the common way, by allowing one and $\frac{1}{2}$ the superficial content of the ground plot) without making any deductions for the holes of the chimney shafts, or vacancies, for sky or lanthorn lights, except 'tis agreed on otherwise.

6. Doors, shop-windows, &c. are measured by the square foot, and also fast frames, &c. stairs and stair-cases are accounted for by the step, in proportion to the nature and goodness of the work.

7. There be divers sorts of work measured by running measure, *viz.* in length only; such as cornices in general, pent-houses, timber fronts, rails and balusters, guttering, lintelling, skirting boards, breftomers, benching, shelving, &c.

II. Of Glaziers work.

Glaziers work is measured by the square foot, and the dimensions are taken in feet, inches, and parts, and the

Of the several Measures, &c.

most material things to be observed therein, are the following.

1. That in measuring of glazing in one building, there are many times windows of one magnitude, and at such times you need measure but one, and thereby account for the others.

2. That semicircle, ovalar, &c. windows be measured, as square windows, whose breadths, &c. are equal to their diameters; and the reason for so doing is, because there is great waste in cutting the glass, and much more time expended therein, than if the whole was a square window.

III. Of Joiners work.

1. Joiners work is measured by the square yard (of 9 feet) but their dimensions are taken in feet and inches, and the product being divided by 9 (the square feet in a yard) the quotient is yards.

2. In taking the dimensions you must observe the following rules.

1. In taking the height of any cornish, wainscot, &c. that you measure with a line into, and about, every moulding, as is contained between the cieling and the floor, which you must call the height, or breadth, and the circumference of the room measured on the floor, the length, which being multiply'd as is taught in sect. I. hereof, and divided by 9, the quotient is the content thereof.

2. When you measure window-shutters, doors, drawers, seats, or pews in churches, &c. you must account the measure $\frac{1}{2}$ as much more that it contains, in regard to its being worked on both sides, and is what workmen call work and $\frac{1}{2}$ work.

3. That in measuring wainscot you always deduct the doors, chimneys, and windows contained therein.

4. That you measure the window boards, sashetas, cheeks, skirt boards, &c. by themselves. And,

Lastly, When joiners make cornice and base, and sub-base, &c. singly, they are measured by running measure, as also architrave and freize.

N. B. That chimney-pieces, frontispieces of doors, ornaments of windows, pediments, &c. are valued according to their goodness, at - - *per* piece.

IV. Of Painters work.

1. Painters work is measured and taken as joiners, both in respect to girting about the moulding, as well as in measuring

measuring the length on the circumference of the floor, &c. and the deductions to be made are the same, but instead of accounting doors, window-shutters, &c. work and half work, they account it all whole work.

2. Window-lights, bars, casements, &c. are done at --- per piece, and oftentimes cantalivers, modillions, &c. and ornaments between them.

V. Of Plasterers work.

Plasterers works are principally of two kinds, *viz.* cieling work which is lathed and plastered, and rendering, which is also of two kinds, *viz.* rendering upon brickwalls free from quarters, &c. and rendering in partitions between quarters, which are all measured by yard measure, taken by feet and inches, and reduced into yards, as before delivered.

The principal things to be observed in taking the dimensions are the following.

1. To deduct chimneys, windows, and doors.
2. To make no deductions (in rendering upon brick) for doors or windows, by reason the jaums and heads, generally exceed the dimensions of the vacancies.
3. That such sommers and girders as lie below a cieling be deducted, if the workman find materials, otherwise not.
4. In rendering, when materials are found by the workman, to deduct $\frac{1}{4}$ for the quarters, but when workmanship only is found, no deduction must be made, for the workman could have rendered the whole as soon as if there had been no quarters there.
5. When you measure whiting and colouring between quarters, you must add a fourth or fifth part, for the returns or sides of the quarters.

Lastly, Ornaments in plaster, as ornaments in cielings, capitals, architraves, freizes, cornices, &c. are measured by foot measure, in length only at ---- per foot according to the goodness and nature of the work.

VI. Of Masons work.

Masons work is measured three different ways, as first, running measure, as the coping of walls, &c. Secondly, superficial, as pavements, &c. And lastly solid, as blocks of marble, &c. which several measures being all performed by the 3 first sections hereof, I need say no more thereof, but that their dimensions are taken in feet, inches and parts.

VII. Of Bricklayers work.

Of bricklayers work there are divers kinds, but the principal are walling, tiling, and paving.

1. Of walling, performed by the rod.

1. Of walls there are divers kinds, in respect to their length, height and thickness's, whose dimensions are always taken in feet and inch measure in respect to length and height, and by the length of a brick, &c. in respect to their thickness.

2. The measure by which brickwalls are accounted is a square rod or 16 feet 6 inches squared, whose product or quantity, is 272 feet square and 36 inches, or $\frac{36}{144}$ whose $\frac{1}{2}$ is 136 feet $\frac{18}{144}$ and quarter 68 feet $\frac{2}{144}$.

3. The manner of measuring brick walls is the very same as any other superficial measure, provided their thickness be exactly the standard thickness, viz. one brick and $\frac{1}{2}$ and the product of the dimensions divided by 272: 26, whereby the number of square rods contained therein may be known.

4. When the thickness of brickwalls exceeds or is less than the standard thickness of one brick and half, they must be reduced thereunto by this general rule.

Multiply the superficial content of the wall by the number of half bricks contained in the thickness, and divide the product by three (the number of $\frac{1}{2}$ bricks contained in the standard thickness of one brick and $\frac{1}{2}$) and the quotient shall be the true content of the wall, reduced to the standard thickness of one brick and half, as required.

5. When brickwalls are of divers thickness they must be severally taken, and their several quantities being added together will be the content of the whole, as required. And here note, that whatsoever doors, windows, &c. are contained in the several thicknesses of such walls, that you deduct them out of the total product of the respective dimensions or thickness, wherein they are situate, and the remainder will be the true content of the work.

6. When you are to measure walls that meet, and constitute an angle, you must take the length of one wall to the out-side of the angle, and the other to the inside.

7. When you have any chimneys to measure, measure them as a solid, and deduct the vacancies, (as taught by *Venterus Mandey* in his appendix of *chimneys reformed* in his *Mellificium Mensionis*) and thereby you will have the

the true solidity; but if you practice the common way of girting chimneys, you never can have the true content, and will always remain in the dark, as many stubborn ignorant conceited fools now are.

2. Of walling, performed by foot measure.

1. This part of walling is that which is called ornament, such as arches over doors, windows, &c. *Facio's*, architraves of doors, windows, &c. freizes, cornices, rustick cones, rubbed returns, &c. and in short all kind of work performed in a rubbing house with ax and stone is ornamental work, and is always performed at ---- *per* foot.

2. When you have any of these ornaments to measure, that have unequal sides, as the arch over a window, &c. you must take the dimension thereof in the middle and thereby 'twill be a mean. And besides the aforesaid ornaments which are performed by foot measure, there are divers other ornaments that are performed -- *per* piece, and such are peers, columns, pillasters, architraves, freizes, cornices, grottos, cascades, pediments, &c. which are valued according to the nature and goodness of the materials and workmanship.

3. Of tiling.

1. As carpenters measure their roofs by the square of 10 feet (*viz.* 100) so also do bricklayers their tiling, whose dimensions are always taken in feet and inch measure, and their products being divided by 100 (the number of square feet in a square) the quotient is the content required.

2. When you take the dimension of a roof, you must first measure the whole length, as far as the tiles are laid, for your length, and from the ridge to the eaves for the depth, and thereby the quantity of tiling will exceed the quantity of roofing, by so much as the tyles go beyond the roof at each end, and over the eaves board.

3. It often happens, that in some roofs there are many hips and valleys, which must be paid for, at ---- *per* foot running measure.

N. B. That what is here said of tiling, the same is be understood of flating.

4. Of paving.

Since it often happens that cellars, kitchens, grottos, &c. are paved by bricklayers, therefore I thought it necessary to mention it here, at the conclusion hereof, where-

in you are to understand, that the dimensions of such work are taken in feet and inch measure, and the content is always given in square yard measure, as plastering, rendering, &c.



S E C T. V.

Of the Manner of casting up the Dimensions of Land Measure taken with Gunter's Chain (which of all others is the best.)

P R O B L E M I.

Suppose an oblong piece of land contain 15 chains 25 links in length, and 13 chains 75 links in breadth, what is the content?

Rule.

1. Multiply 15 : 25, by 13 : 75, according to the common way of vulgar multiplication, and the product will be 20,96875, from which cut off the five last figures towards the right hand, *viz.* 96875, and the remainder to the left, *viz.* 20, is the number of acres.

2. Multiply the five figures cut off by 4 (the number of roods in an acre) and the product will be 387500, from which cut off five figures, as before, and the remaining is roods.

3. Multiply those figures last cut off by 40 (the number of square poles in a rood) and the product is 3500000, from which cut off five figures, as before, and the remainder is poles.

Lastly, If any numbers remain in the last five figures cut off, multiply them by $272\frac{1}{4}$, and cut off five figures, as before, and the remainders to the left, shall be the odd feet, which in land measure is exact enough. See the operation.

Length

Length	15:25	
Breadth	13:75	
	<hr/>	
	7625	
	10675	
	4575	
	<hr/>	
	1525	
Acres	20)96875	These five figures
Multiply by	<hr/>	The roods in an acre.
	4	
Rods	3)87500	These five figures
Multiply by	<hr/>	The poles in a rod.
	40	
Poles	35)00000	

PROBLEM II.

PLATE XVII.

The plan of a piece of land with the area given, to find the scale by which it was plotted, supposing such a scale was left.

Suppose A B, C D, to be a plan, equal in area to 34 acres 31 centesims, I demand by what scale the figure was plan'd.

1. If you measure the side A B with a scale of 10 in an inch, the length A B will contain 38 chains and 12 centesims, and the breadth A C 6 chains and 25 centesims. The content will be found to be 23 acres and 82 parts. Wherefore if you divide the distance on the scale of logarithms between 23:82, and 34:31 into two equal parts, and setting one foot of your compasses upon 10, the imagin'd scale, the other will reach to 12, which is the scale required.

PROBLEM III.

Of the mensuration of turf, with which grass walks, plots, &c. are made. The turf used in these works, is the finest that can be had, from commons, beaths, &c. which are generally cut at one shilling per 100, every turf being one foot in breadth and three foot in length. Therefore to find what quantity of turf will cover any walk, &c. find how many square feet are contain'd therein, and divide that number by 3, the number of feet in a turf, and the quotient will be the number of turf required. As for example,

Of the Manner of casting up

There is a walk to be turf'd, whose length is 100 foot, and breadth 16 feet, how many three foot turf will cover the same, supposing no waste to be made?

The length	100	
The breadth	16	
Product	1600	Which divide by 3, as follows.
	3) 1600	(533 $\frac{1}{3}$ the number of turf re-
	1500	quired.
	<hr/>	
	10	
	9	
	<hr/>	
	10	
	9	
	<hr/>	
	1	remains.

Note, That this calculation supposes no waste to be made, which in laying them is impossible. Therefore the usual allowance for waste is as follows, *viz.* a hundred of turf, which contains 300 foot, is allowed to completely finish one rod of ground, which contains 272 $\frac{1}{4}$ feet.



S E C T. VI.

Of divers Analogies, or Proportions, in Land Measure.

Proportion I.

Having the length and breadth of an oblong given in chains, to find the contents in acres.

As 10 is to the breadth in chains, so is the length in chains to the content in acres.

Proportion II.

Having the perpendicular and base of a triangle given in perches, to find the content in acres.

As 320 is to the perpendicular, so is the base to the content in acres.

Proportion

Fig: I.

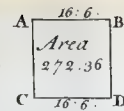


Fig: X.

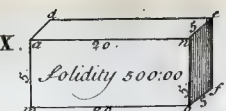


Fig: XVI.

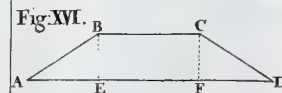


Fig: III.

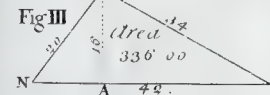


Fig: XI.



Fig: IV.



Fig: XII.

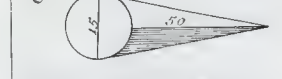


Fig: V.

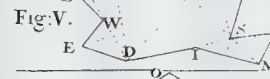


Fig: XIII.

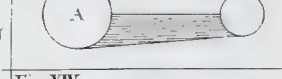


Fig: VI.

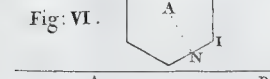


Fig: XIV.



Fig: VII.

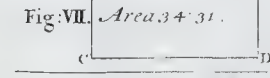


Fig: XVII.

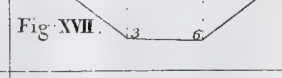


Fig: IX.

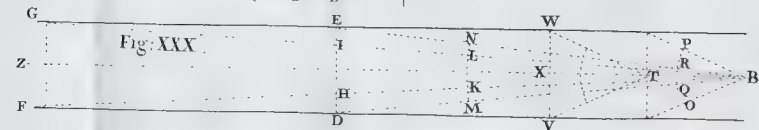
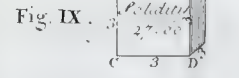


Fig: XXII.



Fig: XXVIII.

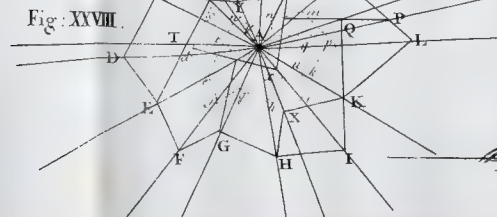
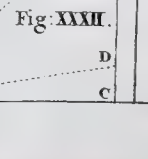


Fig: XXXII.





Proportion III.

Having the perpendicular and base of a triangle given in chains, to find the content in acres.

As 20 is to the perpendicular, so is the base to the content in acres.

Proportion IV.

Having the content of a superficies in one kind of measure, to find the content of the same superficies, according to any kind of perch measure.

As the length of the second perch is to the length of the first perch, so is the content in acres to a fourth number, and the fourth number to the content in acres required.

Proportion V.

Having the length and breadth of an oblong superficies given in perches, to find the content in acres.

As 160 is to the breadth in chains, so is the length in perches to the content in acres.

Proportion VI.

Having the length of a superficies in chains, to find the breadth of an acre.

As the length in chains is to ten, so is one acre to the breadth in chain measure.





T H E
P R A C T I C E
O F

*Architecture, Gardening, Mensuration, and
Land-Surveying, Geometrically demonstrated.*

P A R T IV.

Containing divers excellent Tables of Mensuration, which shew, by inspection, the true superficial, or solid Content, of any Kind of Measure, according to any Dimensions given.

S E C T. I.

Of English Measures used in Lands and Buildings.

BEFORE I begin the tables, 'twill not be improper to insert the following measures, viz. That

A square foot	Contains	144 square inches.
A cubical foot		1728 cubical inches.
A square yard		9 square feet.
A cubical yard		27 cubical feet.

A square		100 square feet, or 10 foot every way.
A load of timber		50 foot cubical.
A load of planks	2	300 square feet.
	3	200 square feet.
	4	150 square feet.
	$1\frac{1}{2}$	400 square feet.
	1	600 square feet.
A geometrical pace		5 feet
A geometrical perch		10 feet
A statute pole or perch		16 feet $\frac{1}{2}$
A square statute perch		$272\frac{1}{4}$ square feet.
A woodland pole or perch		18 foot in length.
A square woodland pole		324 square feet.
A forreft pole or perch		21 foot in length.
A square forreft pole		441 square feet.
4 statute perches		One chain length.
10 chains length		A furlong or acre's length.
4 chains length		An acre's breadth.
40 square perches		A rood or $\frac{1}{4}$ acre.
4 rood, or 160 perches		An acre.
A hide of land		100 acres

Bricks according to the statute, should be 9 inches in length, 4 inches $\frac{1}{2}$ in breadth, and 2 inches $\frac{1}{2}$ in thickness; 500 is a load. Plain tile, in length 10 inches $\frac{1}{2}$, breadth 6 inches $\frac{1}{4}$, and thickness $\frac{3}{4}$ inch; 1000 is a load. Gutter tile in length 10 inches $\frac{1}{2}$, the breadth and thickness in proportion. Roof tile in length 13 inches, thickness $\frac{1}{2}$ inch and $\frac{1}{2}$ quarter, the depth proportional. Lath 5 score to the bundle, when 5 foot long; but when 4 foot in length, then 6 score to the bundle. Deals and nails 120 to the hundred. Lime is sold by the bag, which should be a bushel, 25 bags is called a hundred; 'tis in some places sold by the load, which is about 40 bushels. A tun of iron is 2240 pound weight; and a fodder of lead 19 hundred $\frac{1}{2}$, or 2184 pound.

S E C T. II.

Of the Explication of the Inspectional Tables of Mensuration.

Table I.

THIS table is design'd for small mensurations, as painting laid with leaf gold, which is generally done for 5 s. per foot, if plain without carving; and if carved, double the price, by reason a great quantity of gold is wasted in gilding the broken parts of the same and glazing, &c. which is costly work, and feldom is in great quantity together.

The use of this table is as follows.

Suppose a piece of gilding, glazing marble, &c. be 11 inches in breadth, what length must be taken for a square foot?

Practice.

1. In the first column (entitled the dimensions breadth in inches) find 11 (the breadth of the work) and against it stands 1, 1, 1, which signifies one foot, one inch, and one tenth part of an inch, and is the length required to make one square foot.

2. To find the content of the whole, open a pair of compasses to the extent of 1 foot, 1 inch, and $\frac{1}{10}$, and run that extent through the whole length of the dimensions, and the number of those extents shall be the number of feet required.

Example 2.

Suppose a flabe of marble is 13 foot 4 inches and $\frac{2}{10}$ of an inch in length, and 23 inches wide at one end, and 17 at the other, what length must be taken for a square foot, and how many doth it contain?

Practice.

1. Add the ends together 23 and 17, and take a mean, viz. 20.

2. A-

2. Against 20 in the first column stands 0, 7, 2, viz. seven inches and $\frac{2}{10}$ of an inch, which is the length of a foot required.

And if the compaffes be opened to that extent, 'twill pafs through the fame exactly 22 times, which is the number of feet contain'd therein.

Note, That what is faid here in relation to the menfuration of marble, the fame is to be understood in any other kind of meafure.

Table II.

This table is calculated for any large menfurations of fuperficial feet meafure, and is divided into 21 columns. The firft contains the dimenfions breadth in inches from 1 to 36. The other 20 columns, contains the dimenfions length in feet. Every of thefe columns is number'd at their heads from 1 to 20 feet, as 1 foot, 2 feet, &c. and under every of thefe numbers in each column, is placed the letters F P, which denote feet and part of feet. And here you are to obferve, that every fquare foot is divided into 100 equal parts, and thofe parts, or numbers written under the letter P in every column, are fo many parts of a hundred or foot. Therefore 25 of thofe parts is a quarter, 50 a half, and 75 three quarters of a foot, and the like of any other centefimal part.

Ufe.

Suppofe a flabe of marble be 22 inches in breadth and 11 foot in length, what's the content?

In the angle of meeting of 22 (accounted from the fide or firft column,) and 11 (accounted from the head) is 20: 16, which is 20 fquare foot and $\frac{16}{100}$ the content required.

Example 2.

There is a marble pavement 12 foot in breadth and 17 foot in length.

When the breadth happens to be greater than 36 inches, as herein, you muft firft work, fuppofing the breadth was 36 inches only, and note that content.

2. As often as you can find 36 in the breadth, fo many times add the firft content (as in this example is 4 times) and if any part of the breadth remain, proceed as at firft, and add that to the fum of the feveral additions and the fum fhall be the content required. I need not add the operation, by reafon 'tis fo very eafy and plain.

Of the Explication of

When measures happen unequal at each end, add them together and take a mean, as in table I.

Tables III, and IV.

These two tables are both calculated for the mensuration of solids, as timber, stone, &c. as are truly square at their ends.

Use of table I.

There is a piece of square timber, whose sides are each equal to 13 inches, what length must be taken for one solid foot?

Practice.

Against 13 in the first column, stands 0, 10, 2, viz. 10 inches and 2 tenths of an inch, which is the length required.

Table II.

Suppose a piece of timber be 16 inches square at each end, and 37 foot in length, what is the content?

Note, That as this table is calculated but to ten foot in length, therefore find the quantity of 10 foot in length first, and then treble it, and afterwards find the quantity of 7 foot in length, and add that to the former, and the sum shall be the solid content required.

Practice.

1. Against 16 in the first column, under 10 feet at the head, stands 17 : 78, which is 17 solid foot, and 78 parts of a hundred.

2. Ten being contain'd 3 times in 37, therefore treble 17 : 78, and the sum will be 53 : 34.

3. For the quantity of the odd 7 foot, look under 7 foot at the head, against 16 of the side, and in that angle of meeting stands 12 : 44, which added to the former 53 : 34, is equal to 65 : 78, viz. 65 foot and 78 parts, which is $\frac{100}{100}$ more than 3 quarters of a foot, and is the solid content required.

Note, That what is said in this example, the same is to be understood in all others of this nature. And because 'tis seldom that timber, or stone, happens exactly square at their ends; therefore I have here subjoin'd a table of mean proportionals, by the help of which any unequal sided timber may be measured by this table, as in the above example.

Table

Table V.

This table of mean proportionals, is calculated on purpose to reduce unequal sided timber, &c. to exact square measure, and thereby the last table is made capable to measure any kind of four sided timber whatsoever.

Use.

Suppose one side of a piece of timber be 19 inches, and the other 7 inches, what is the mean proportional, or what is the length of the side of a square equal thereunto?

Practice.

1. Against 7 in the first column stands 084509, and against 19 stands 127875.

2. Add those 2 numbers of the second column into one sum, and 'twill be equal to 212384.

3. Divide this last number into 2 equal parts, then will the half be 106192.

4. Look for this number (or the nearest to it) in the table which is 107918, against which stands 12, which is the length of the side of a square equal thereunto, as required.

The side of the square being thus found, enter the last table therewith, with any length assign'd, and proceed as therein directed (which is very plain and familiar, and the solid content will be found, as required. But to make it fully plain, take this example.

Let the length be 9 foot.

First, Look for 12 inches in the first column, and under 9 foot (at the head of the table) stands 9: 0, viz. 9 foot, 0 inches, which is the solid content required.

Table VI.

The absolute reason of the construction of this table, is to shew the great error and deceit as is contain'd in the customary way of measuring timber, and to prevent the practice thereof for the future.

The manner of using this table is exactly the same as the first and third. The column, wherein the words, the girt, &c. are inserted, is numbered from 10 to 100. The other column contains the feet, inches, and tenth parts of an inch, as will make a solid foot in length at every circumference of the first column.

M m

Example.

Example.

There is a piece of round timber that in the middle is 52 inches girt (or circumference) and 40 foot in the length, what's the solid content?

Practice.

1. In the first column find 52 the girt given, and against it stands 0, 8, 0, which is 0 feet, 8 inches, and 0 parts, and is the length of a solid foot, at that girt.

2. Take the distance of 8 inches in your compasses, and run them along the piece of timber in a right line, and as often as that distance is found therein, so many solid feet is contain'd in that piece of timber, which in this example is 60 times, and therefore the solidity is 60 foot, or one load and ten foot.

Now for a demonstration of the aforesaid error and deceit in the customary way of measuring, I'll measure the aforesaid piece of timber, according to the common way, which is to double the string by which the girt is taken 4 times, or to take $\frac{1}{4}$ of the girt for the side of a square, and then measure the same as square timber, as follows.

1. The aforesaid girt is 52, one fourth thereof is 13. The side of a square (which they suppose to be, or at least say is true, tho' infinitely from it.)

2. The piece of timber being 40 long (and the fourth table hereof being calculated but to 10 foot length) therefore measure one fourth only, and quadruple it, so shall the mult be the content required. As for example.

Against 13, the side of the square, and under 10 foot at the head of the table, stands 11 : 74, the solid content of 10 feet in length, which quadrupled is equal to 46 feet and 96 hundred parts, which is almost 47 feet.

From hence it appears, that the true content by the first (and true) way, is 60 feet complete, and by this way not quite 47 feet. Therefore 'tis 13 feet too little, or less than the true quantity.

Now suppose the aforesaid piece of timber was oak, which is never sold for less than one shilling per foot, then will the aforesaid loss of 13 feet be 13 shillings at least. Therefore,

If in 60 foot there is but 47 foot accounted for, in 50 foot there is but 39½ foot accounted for, and in every 50 foot, or load of timber, there is almost 11 foot of timber lost, which, as before, is worth at least eleven shillings.

Now if in one load of timber eleven fhillings is loft, what in a hundred? Answer, 55 pound.

So that from what I have here delivered, 'tis evident, that all fuch gentlemen as have fold large quantities of timber, by the common way of meafuring, have been actually cheated of $\frac{1}{5}$ of the fame. But as I have taken the pains here, not only to demonftrate the fame, but alfo to lay down eafy plain rules and tables, 'tis hoped that the fame will put a final end to all fuch impoftors dealings.

Table VII.

This table is calculated as well for the ufe of the farmer, &c. to divide and lay out his corn-lands, meadows, &c. as for a gentleman to meafure and let, difpofe, purchafe, &c. when a furveyor is not to be had eafily, &c.

This table is of 4 parts, each part being divided into 5 columns, and every column into two others. That of the firft, entituled, the breadth of the land, hath two rows of figures, thofe to the left are poles or perches, and thofe to the right hand are quarters or fourth parts of a pole or perch, and are diftinguifhed at the head, by the words perch and $\frac{1}{4}$ parts.

The other columns have at their heads the words 1 rood, 2 rood, 3 rood and one acre, and underneath thofe words the letters P. pts. &c. the letter P in every column fignifies perch, and the letters pts. hundred parts of a pole or perch.

I do advife the practitioner to have a $\frac{1}{2}$ pole or perch, divided into 5 equal parts, and one of thofe parts fubdivided into ten equal parts, fo will the whole be in effect divided into 50 parts, and will be anfwerable to the hundred parts of a perch, as is exprefs'd in the table. Thefe divifions are beft represented by broad-headed nails, with the number of the divifion engraved on the head of each nail.

The ufe of this table is as follows.

Suppofe a piece of land be 7 poles in breadth, how much in length will make one rood, two rood, or an acre?

Practice.

Againft 7 poles in the firft column, ftands in the fecond 5 perch 76 parts, the length of one rood, and in the fecond 11 perch 42 parts the length of two roods, and in the

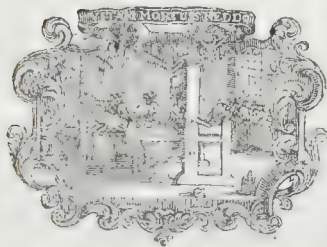
the third 17 perches, 28 parts, and in the fourth 22 perches 85 parts, the length of an acre required. So also had the breadth of the land been 7 poles and 1 quarter, then would the several lengths be as follows, *viz.*

	Perch. Parts.		
The length of	1 rood	5 52	} And the like of any other breadth.
	2 rood	11 4	
	3 rood	16 56	
	Acre	22 8	

By the example last mention'd it appears, that as often as 22 perches and 8 hundred parts is contain'd in the length of any field, as is 7 poles and $\frac{1}{4}$ in breadth, so many acres is contain'd therein, and if at last any length is remaining as is less than an acre, measure off such a length, as that for 3 roods, 2 roods, or 1 rood, &c. as you find will be contain'd therein, and thereby you may have the true quantity to less than $\frac{1}{4}$ of an acre. And to find the true measure of the remaining part as is less than one rood, divide the space of 5 perch 52 parts, into 40 equal parts, and as many of those parts as are contain'd in the remaining part, is the number of odd perches, and thereby you have the whole content, in acres, rood, and perches, as land is generally measured.

A very little practice will make this very plain and familiar, and therefore I recommend you to the same, during which I shall employ my pen in other important parts of architecture and gardening which I shall communicate in another treatise very speedily for publick benefit.

F I N I S.



Page 136

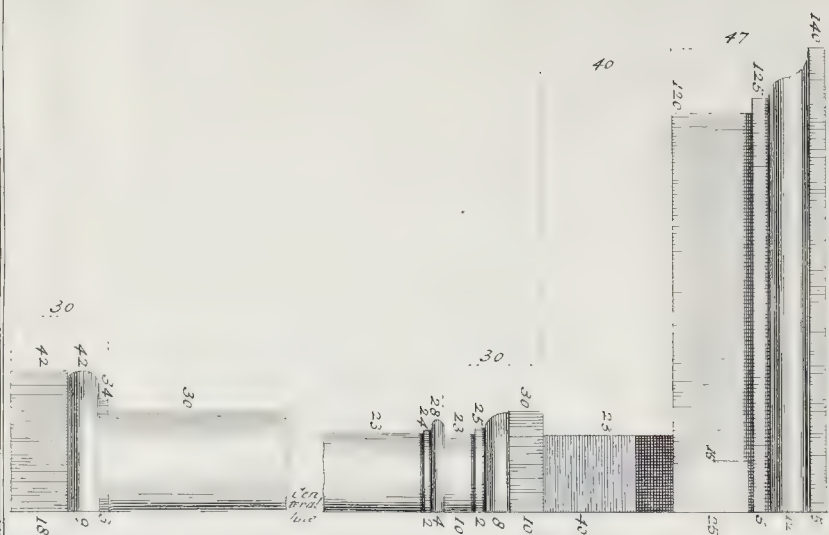
An INSPECTIONAL TABLE of LAND MEASURE Shewing the Superficial Content of any quantity of Land. As also, How to Divide Lands in Common Fields or Inclosures, according to any Proportion Assigned.



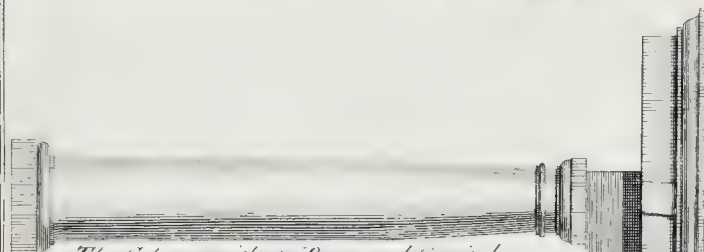


INGO JONES

in y^e Grand Porico of S^t Pauls Covent Garden.

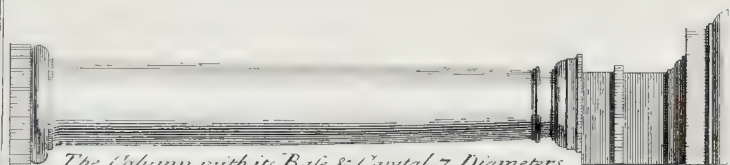


INGO JONES in the
Grand Porbo of
St. Pauls Covent Garden



The Column with its Base and Capital.

M. ANGEL O.



The Column with its Base & Capital 7 Diameters.

A. BOSE.



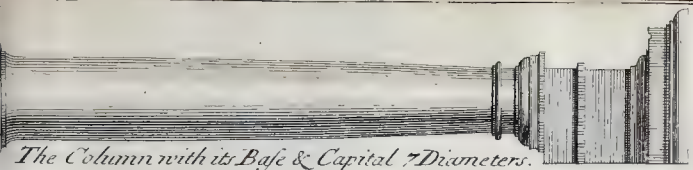
The Column with its Base & Capital 7 Diam. & $\frac{1}{3}$.



The Column with its Base & Capital 7 Diam. & $\frac{1}{3}$.

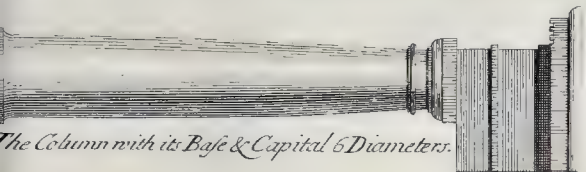
Profiles of the TUSCAN Order, According to
the Proportions of

VIGNOLA.



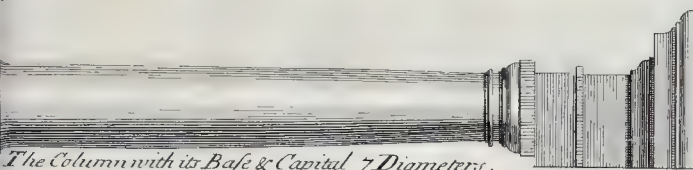
The Column with its Base & Capital 7 Diameters.

S. SERLIO.



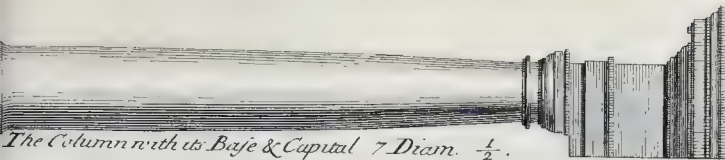
The Column with its Base & Capital 6 Diameters.

VITRUVIUS.



The Column with its Base & Capital 7 Diameters.

SCAMOZZI.



The Column with its Base & Capital 7 Diam. $\frac{1}{2}$.

PALLADIO.

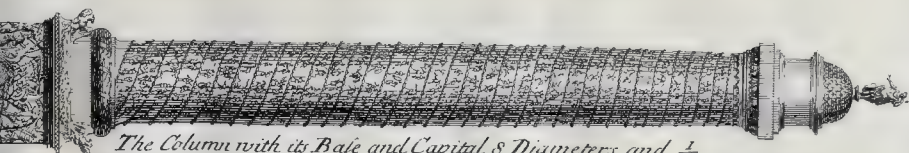


The Column with its Base & Capital 7 Diameters.

LE CLERC.

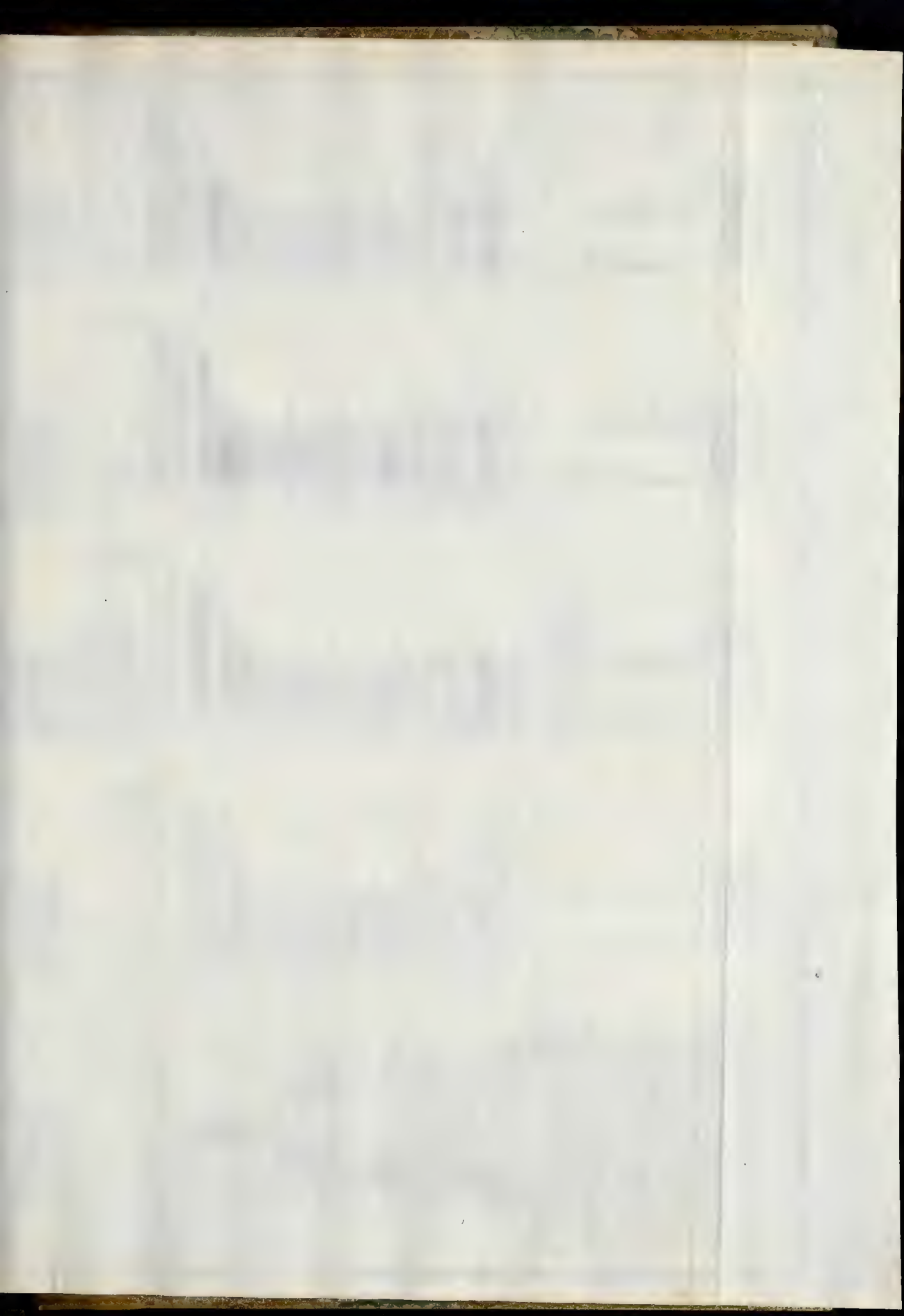


The Column with its Base & Capital 7 Diameters.



The Column with its Base and Capital 8 Diameters and $\frac{1}{2}$.







Members
Projecture

VITRUVIUS.

Members
Height

Members
Projecture

SCAMOZZI.

Members
Height

Members
Projecture

PALADIO.

Members
Height

Members
Projecture

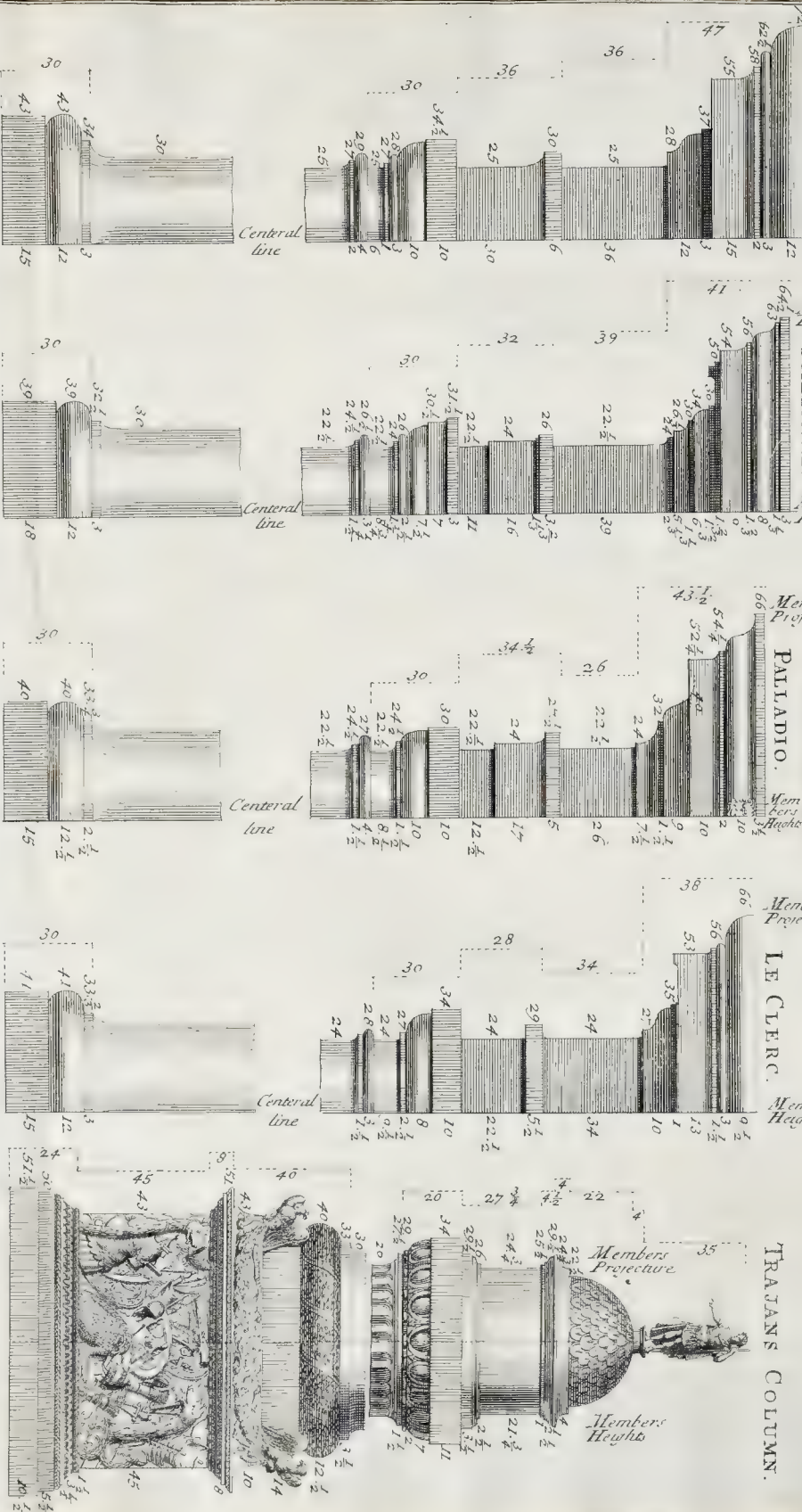
LE CLERC.

Members
Height

TRAJANS COLUMN.

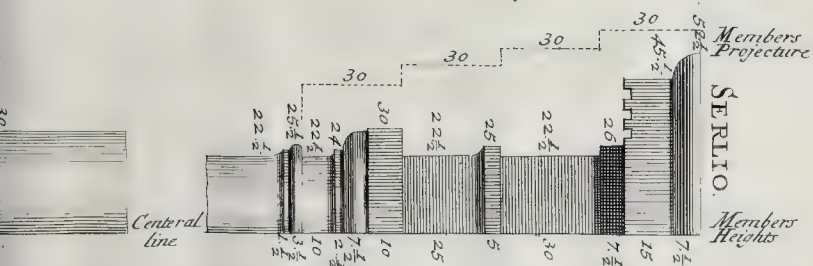
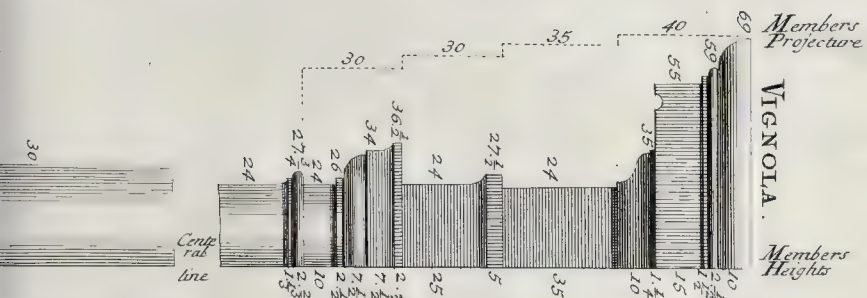
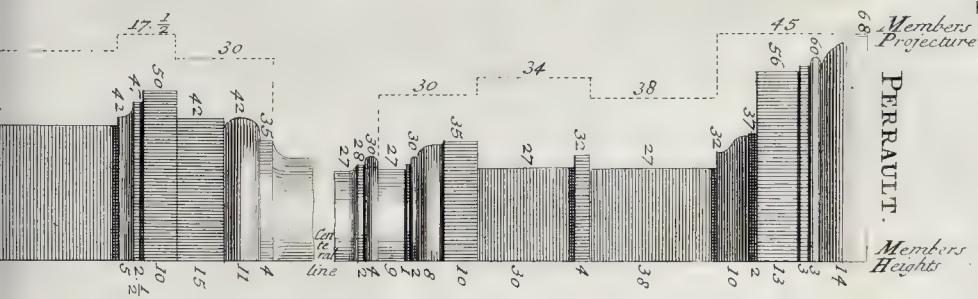
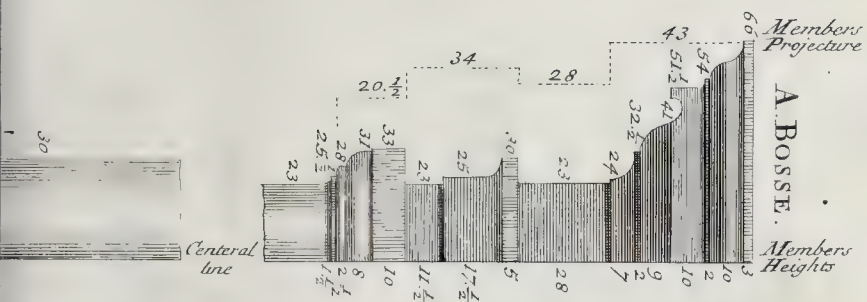
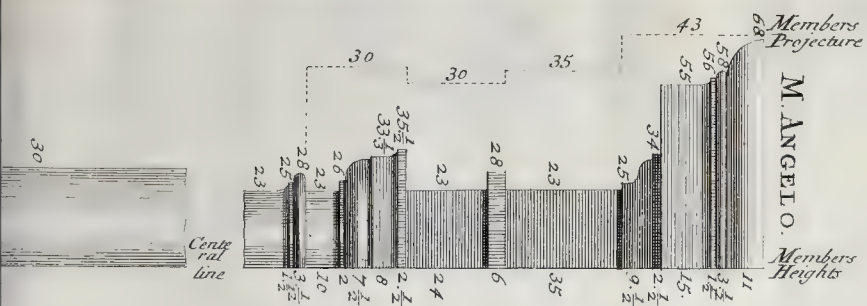
Members
Projecture

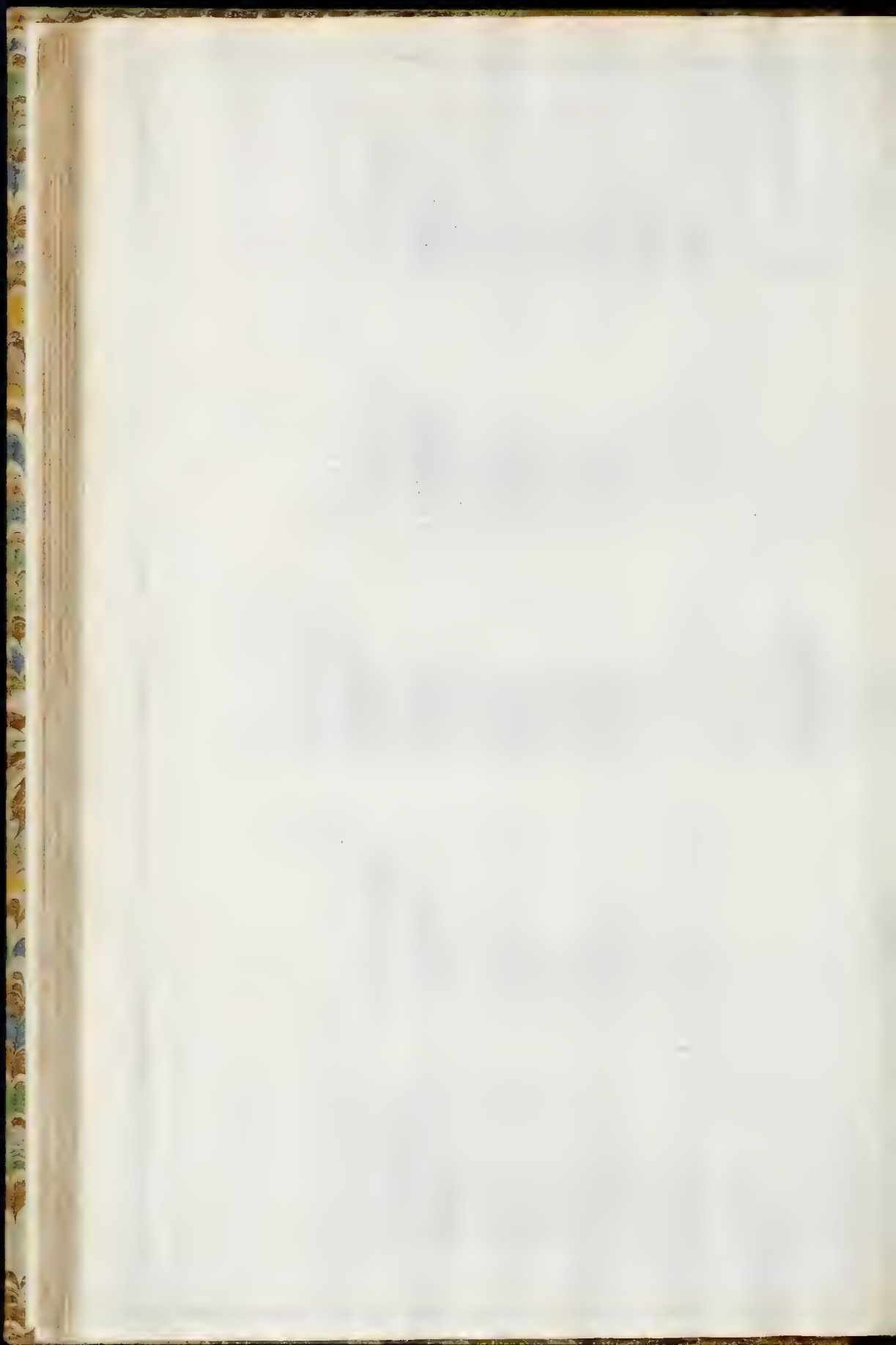
Members
Height



Geometrical Elevations of γ Tuscan Base, Capital and Entablature According to the Proportions of

PLATE XIX

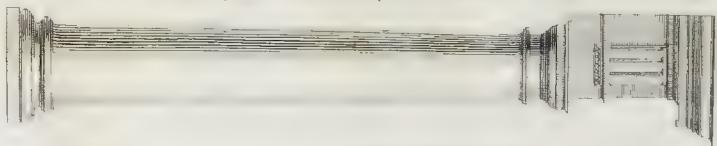




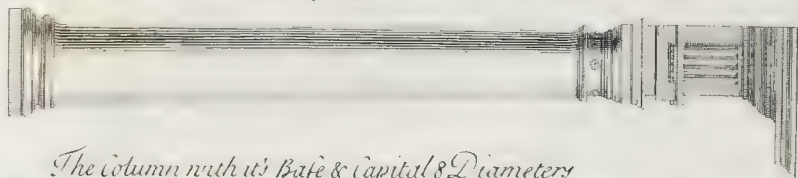


CATANEO. LBALBERTI. VIOLA. IBULANTI. DELORME. PERRAULT. LE CLERC. ABOSSE. MANGILO.

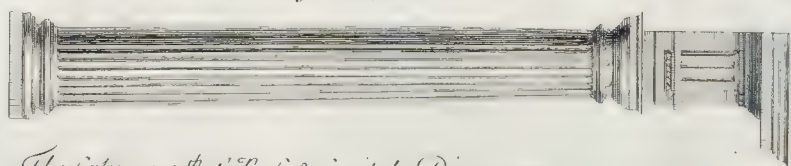
The Column Base and Capital 7 Diameters



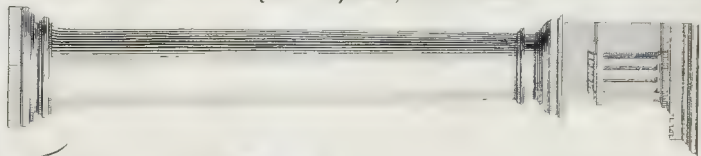
The Column with its Base & Capital 8 Diameters



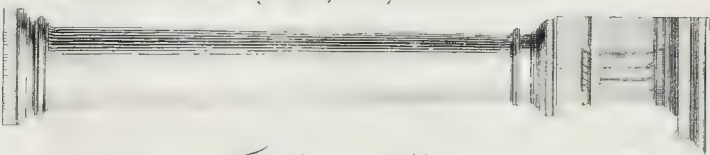
The Column with its Base & Capital 8 Diameters



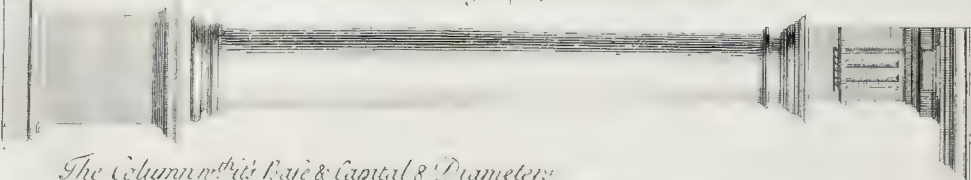
The Column wth its Base & Capital 7 Diameters



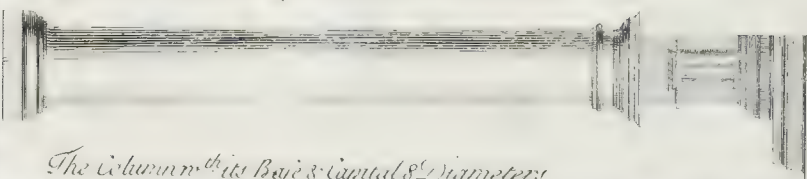
The Column wth its Base & Capital 7 Diameters



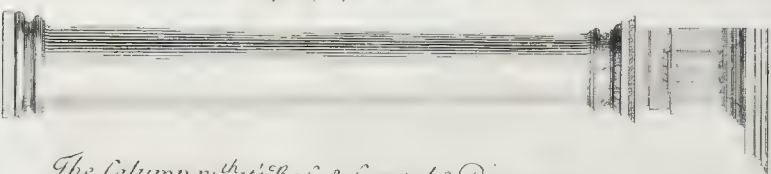
The Column wth its Base & Capital 8 Diameters



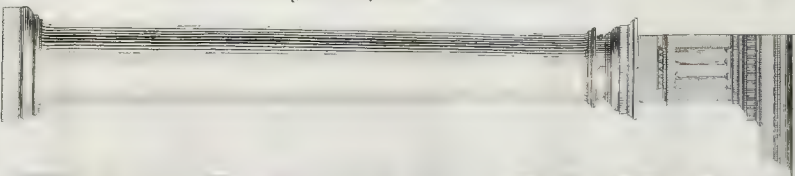
The Column wth its Base & Capital 8 Diameters



The Column wth its Base & Capital 8 Diameters



The Column wth its Base & Capital 8 Diameters



PROFILES OF THE DORICK ORDER

according to the Proportions of

taken

from

The Theatre
of
MARCELLUS -
in
ROME.

The Bath
of
DIOCLETIAN
in
ROME.

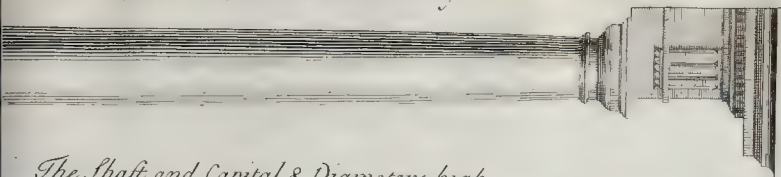
ALBANE
near
ROME.

VITRUVIUS.
PALLADIO.

SCAMOZZI. SERLIO.

VIGNOLA. D'BARBARO

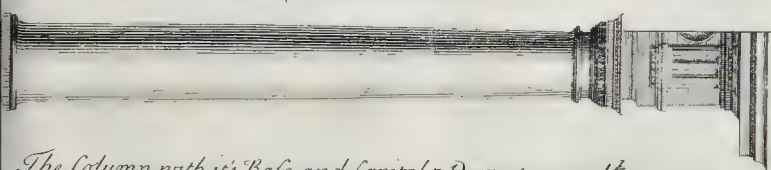
The Shaft and Capital 8 Diameters high



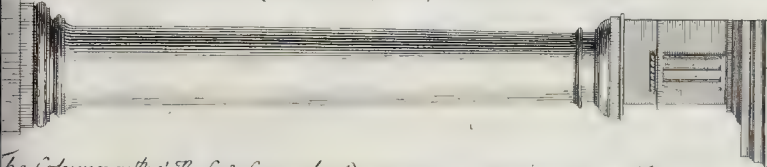
The Shaft and Capital 8 Diameters high



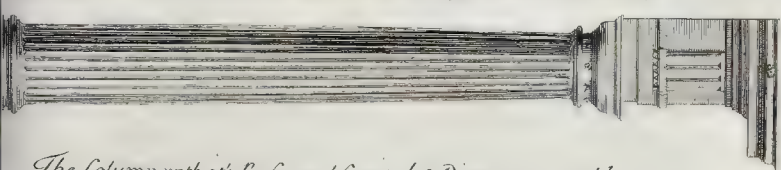
The Shaft and Capital 7 Diameters and 1/2



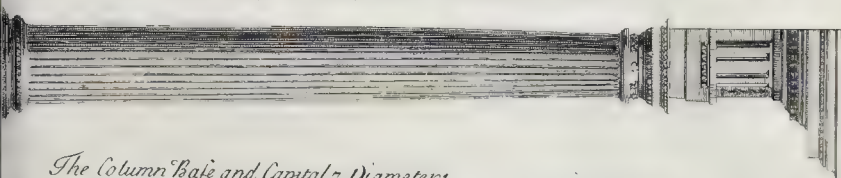
The Column with its Base and Capital 7 Diameters and 1/2



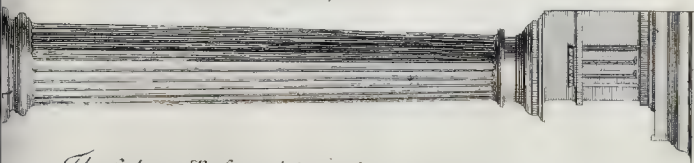
The Column with its Base & Capital 8 Diameters & sometimes 8 and 1/2



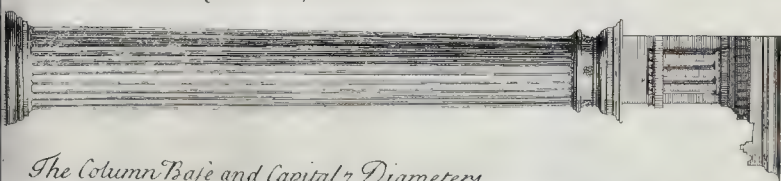
The Column with its Base and Capital 8 Diameters and 1/2



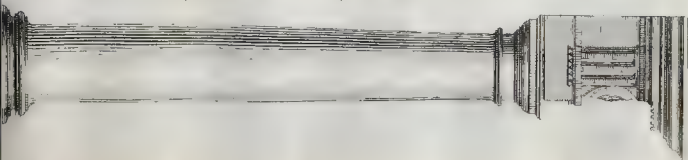
The Column Base and Capital 7 Diameters



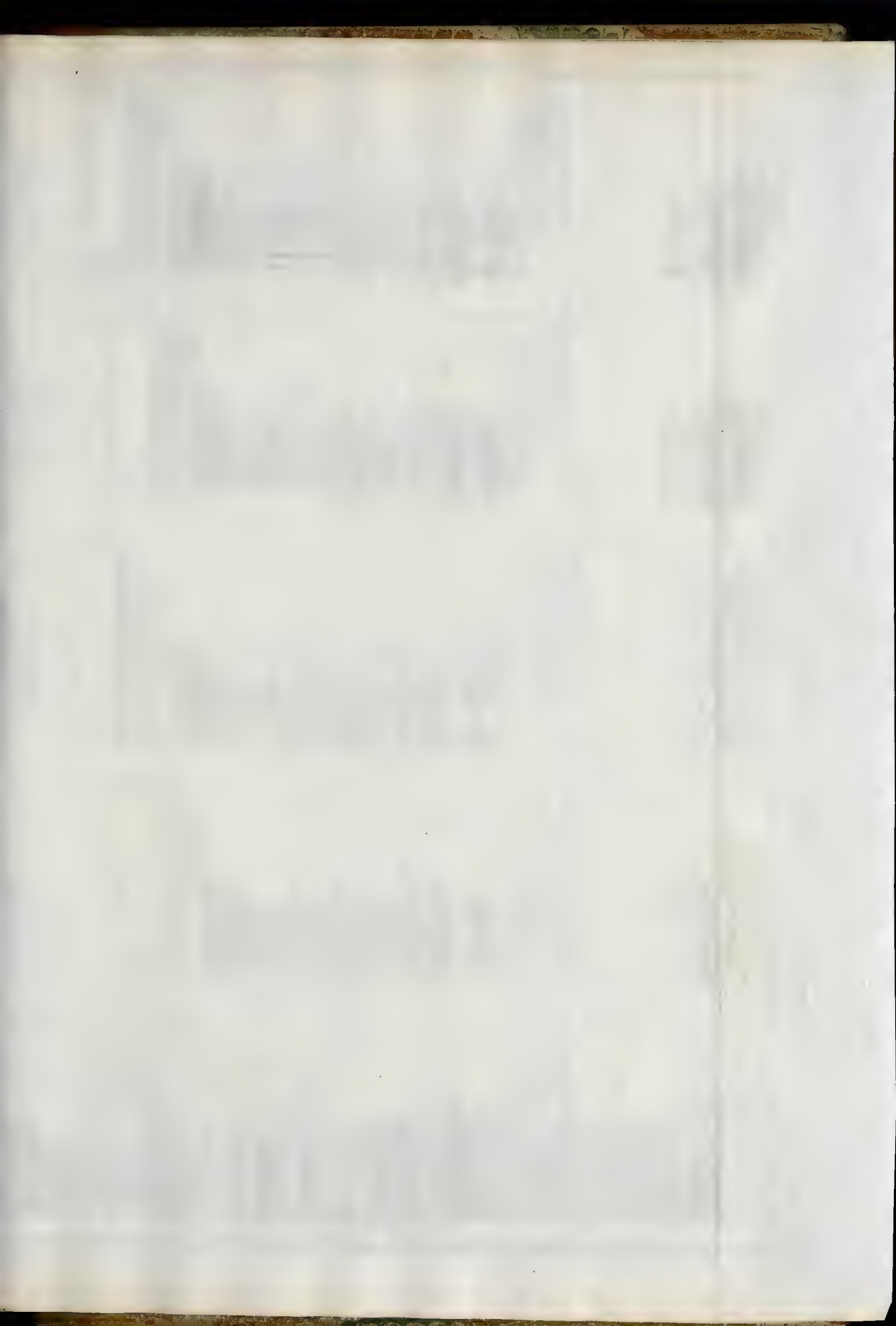
The Column Base and Capital 8 Diameters



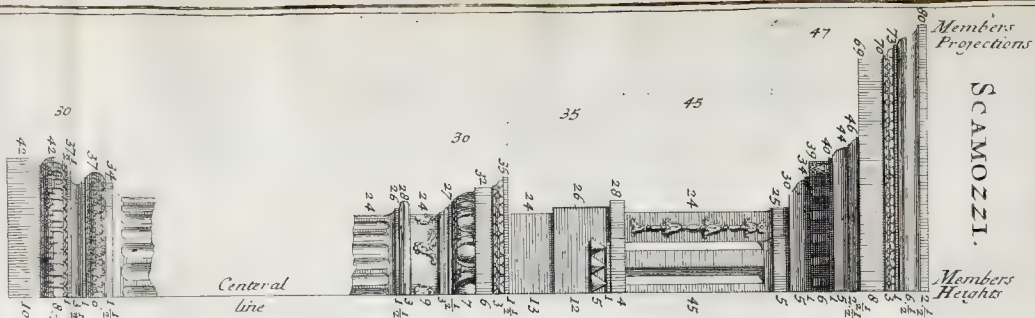
The Column Base and Capital 7 Diameters



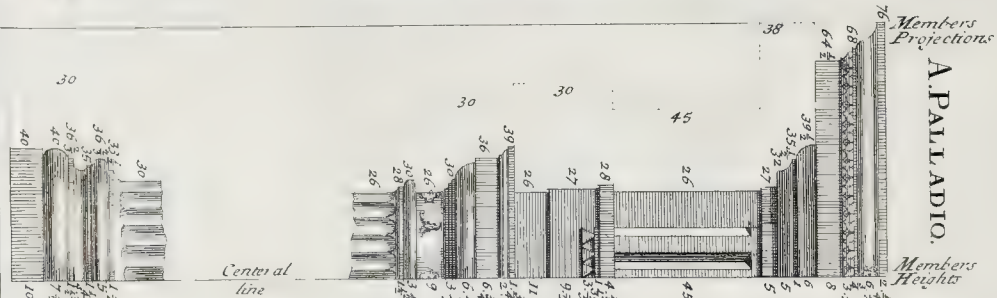




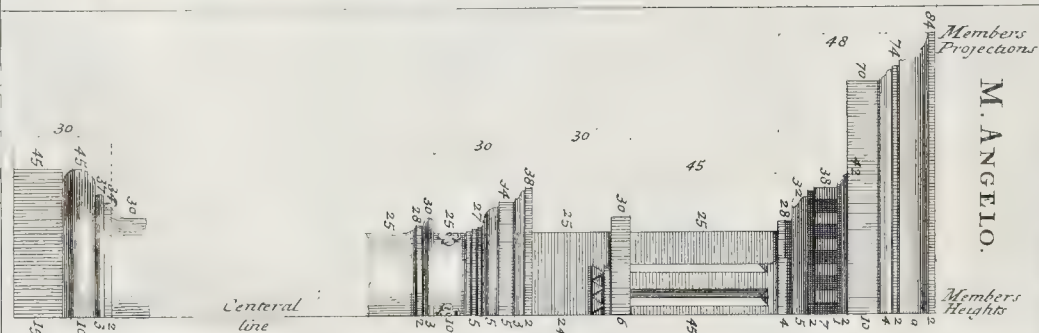
SCAMOZZI.



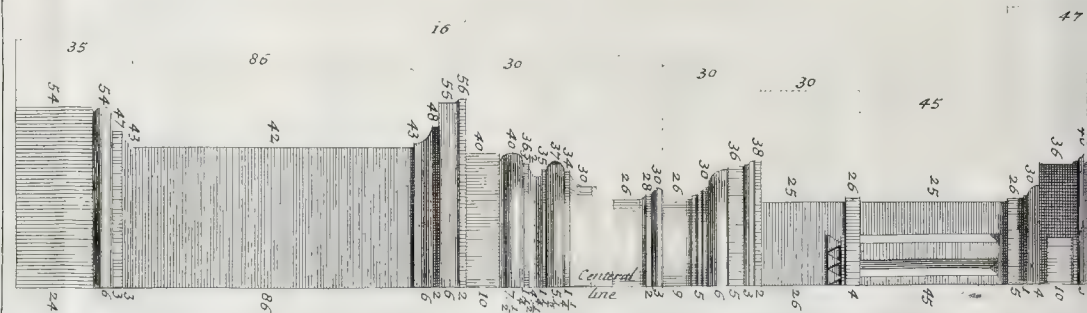
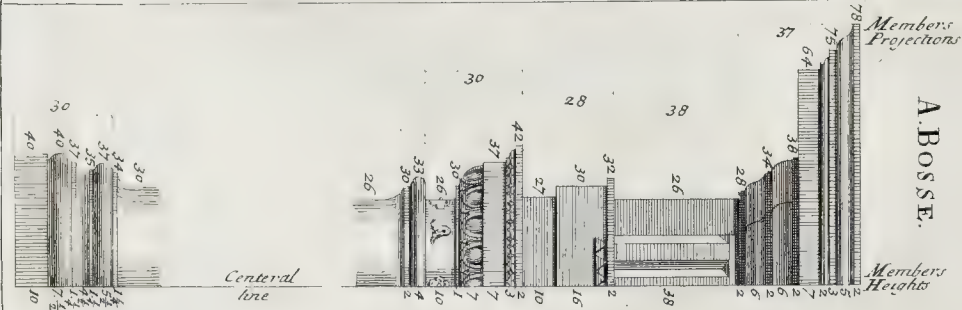
A. PALTADIO.



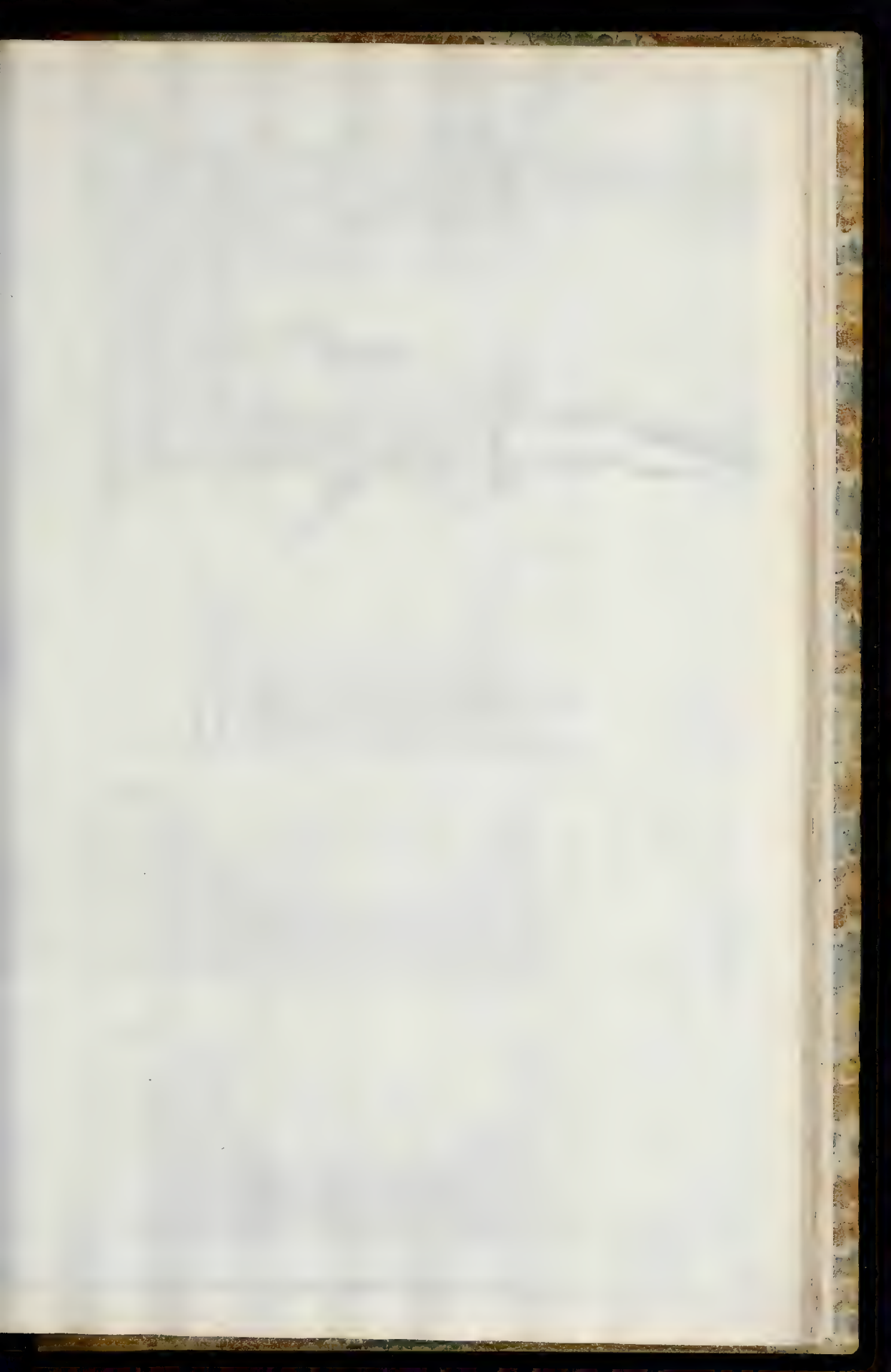
M. ANGELO.



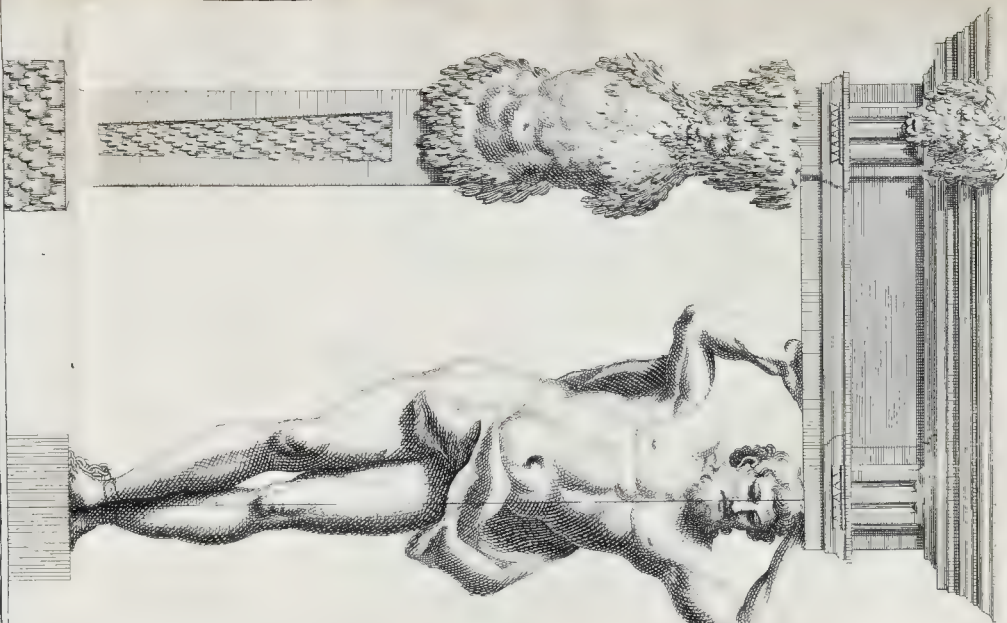
A. BOSE.





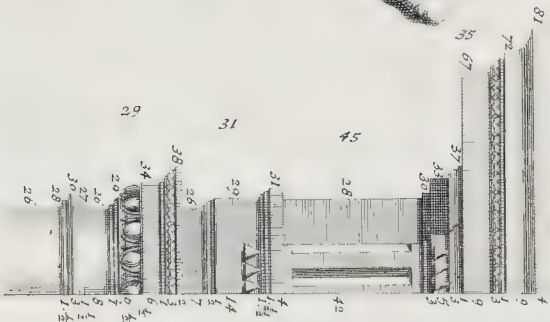


The *PERSIAN* Order.



Members
Projections

ALBANE
near
ROME

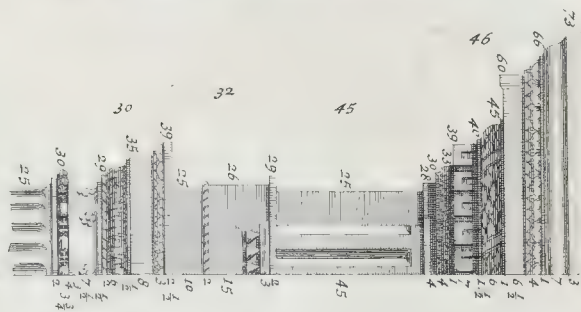


Central
line

Members
Heights

Bath of
DIOCLETIAN
at
ROME.

Members
Heights

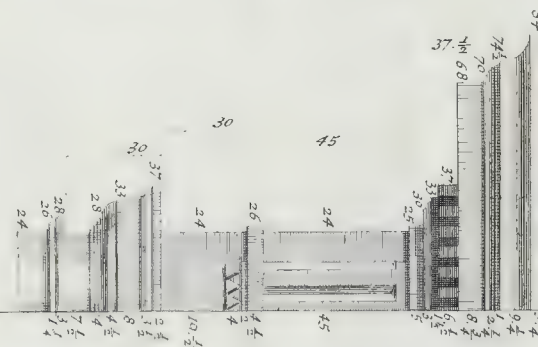


Central
line

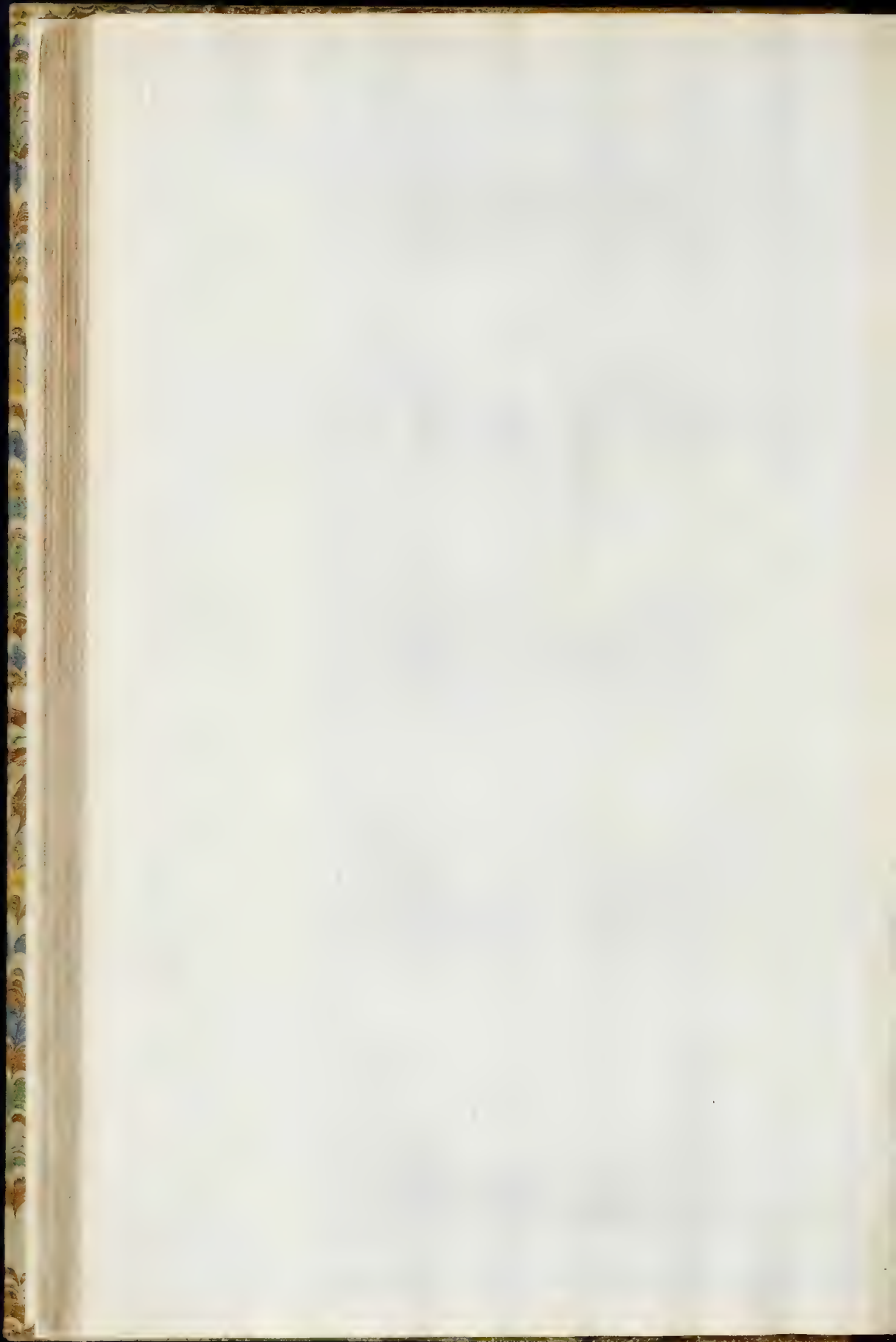
Members
Projections

Theatre of
MARCELLUS
at
ROME.

Members
Heights



Central
line







CATANEO.

L.B. ALBERTI.

VIOLA.

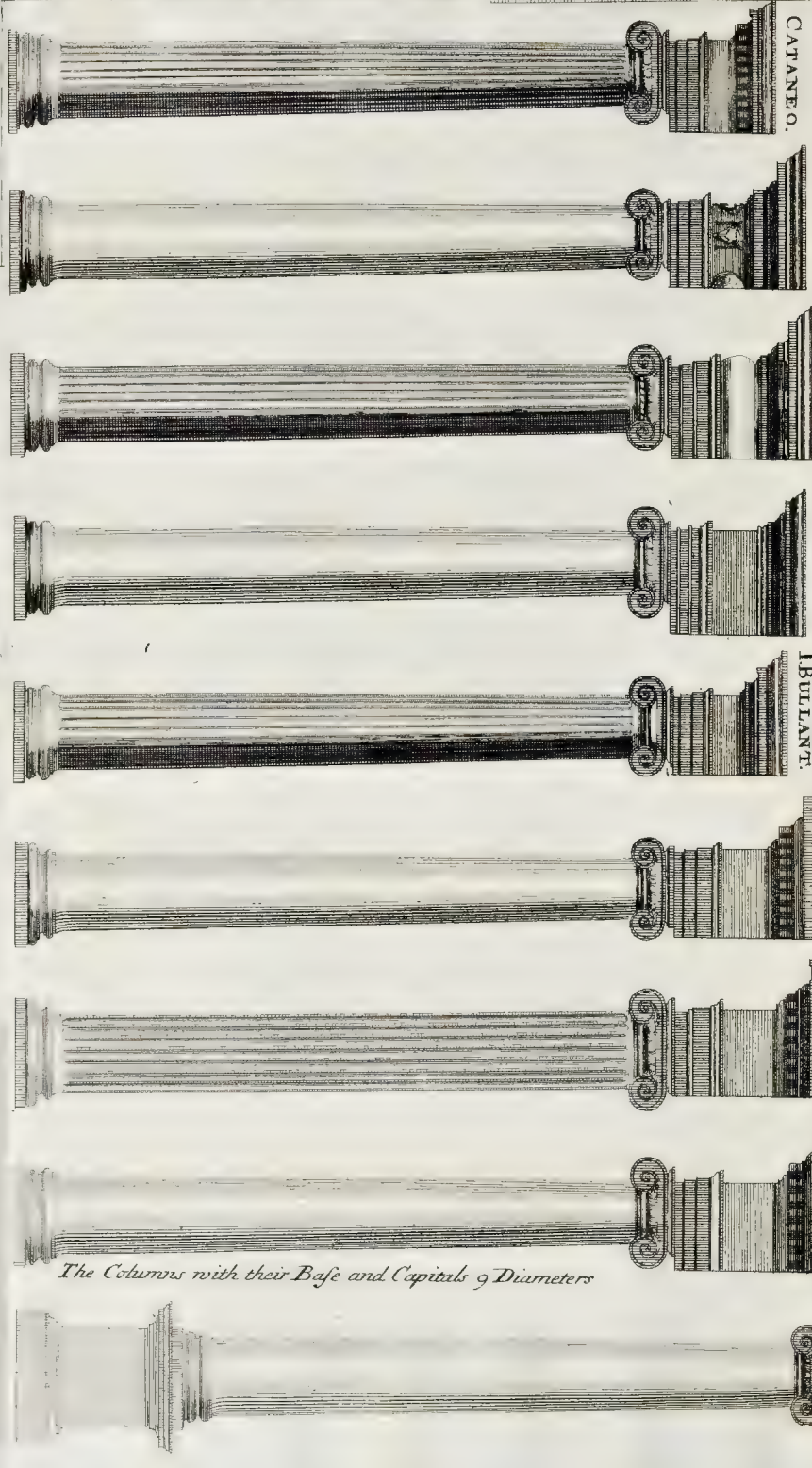
PDE LORME.

IBULLANT.

A. BOSSE.

LE CLERC.

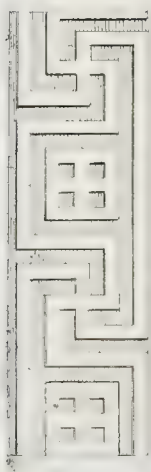
M. ANGELO.



*The Fret
by the*



*Work. Used
Ancients.*



The Columns with their Base and Capitals 9 Diameters

Profiles of the *IONICK* Order, According to

The Temple of
Mans Fortune
at ROME.

The Theatre of
MARCELLUS.

The Bath of
DIOCLETIAN.

VITRUVIUS.

PALLADIO.

SCAMOZZI.

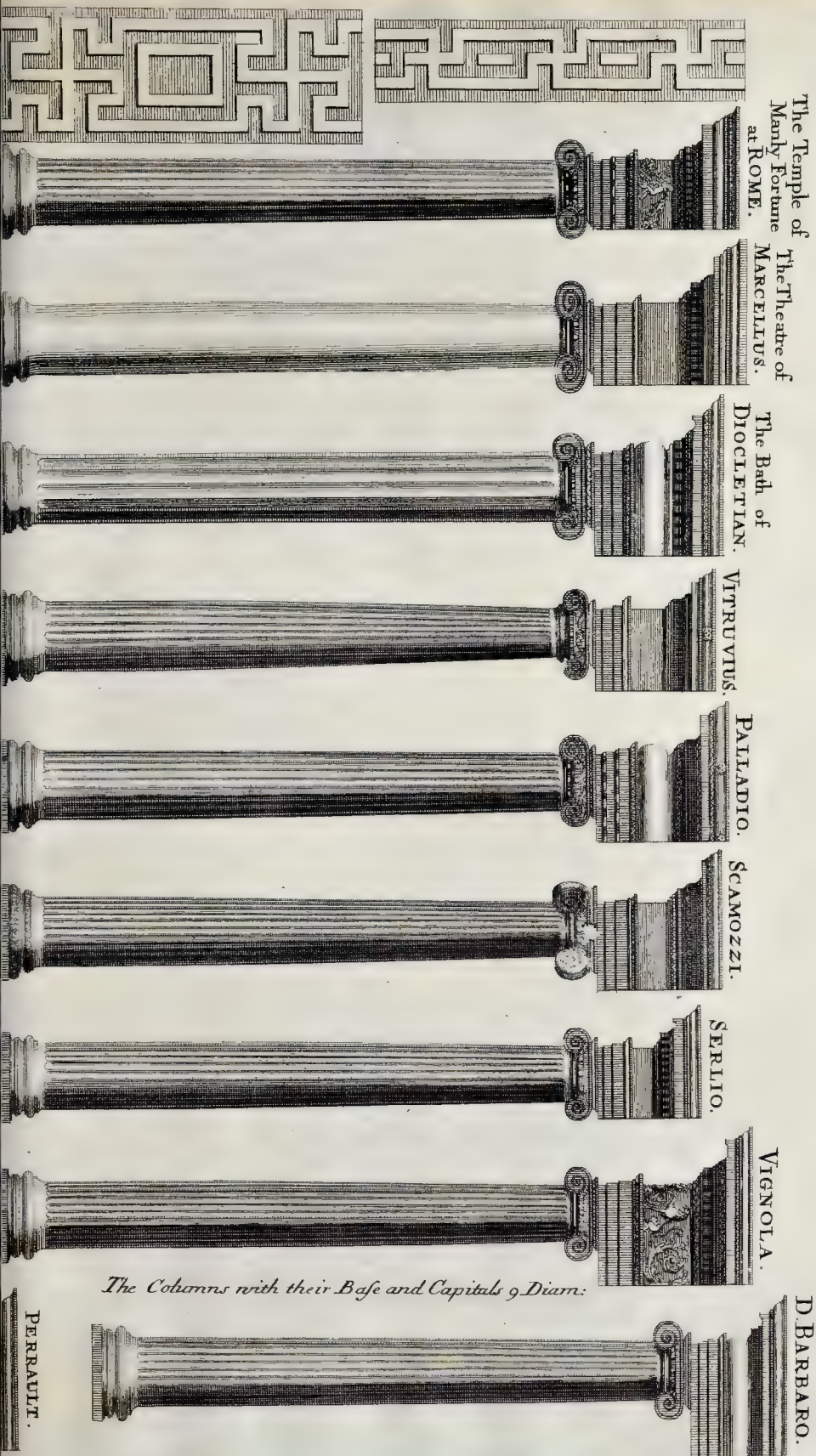
SERLIO.

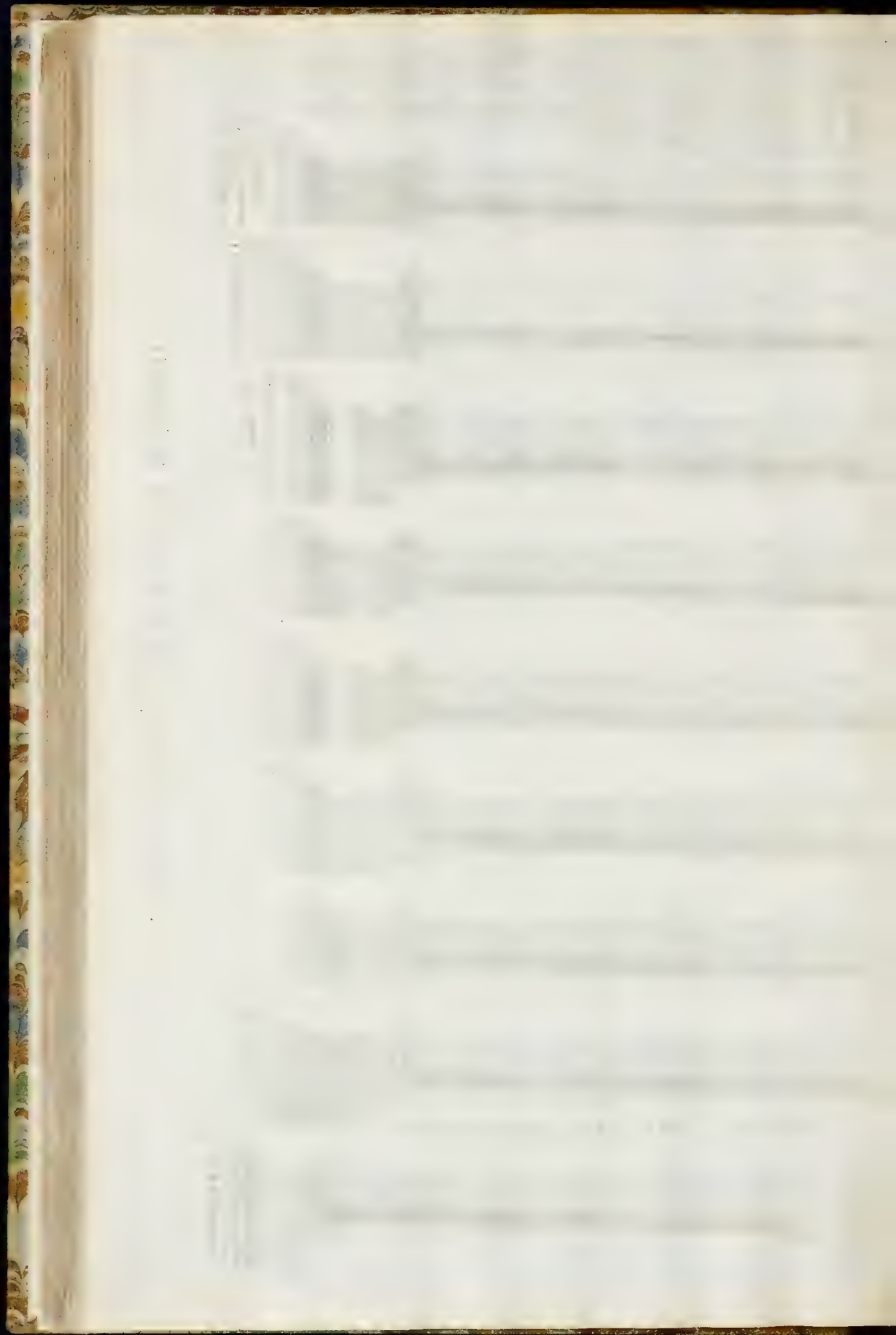
VIGNOLA.

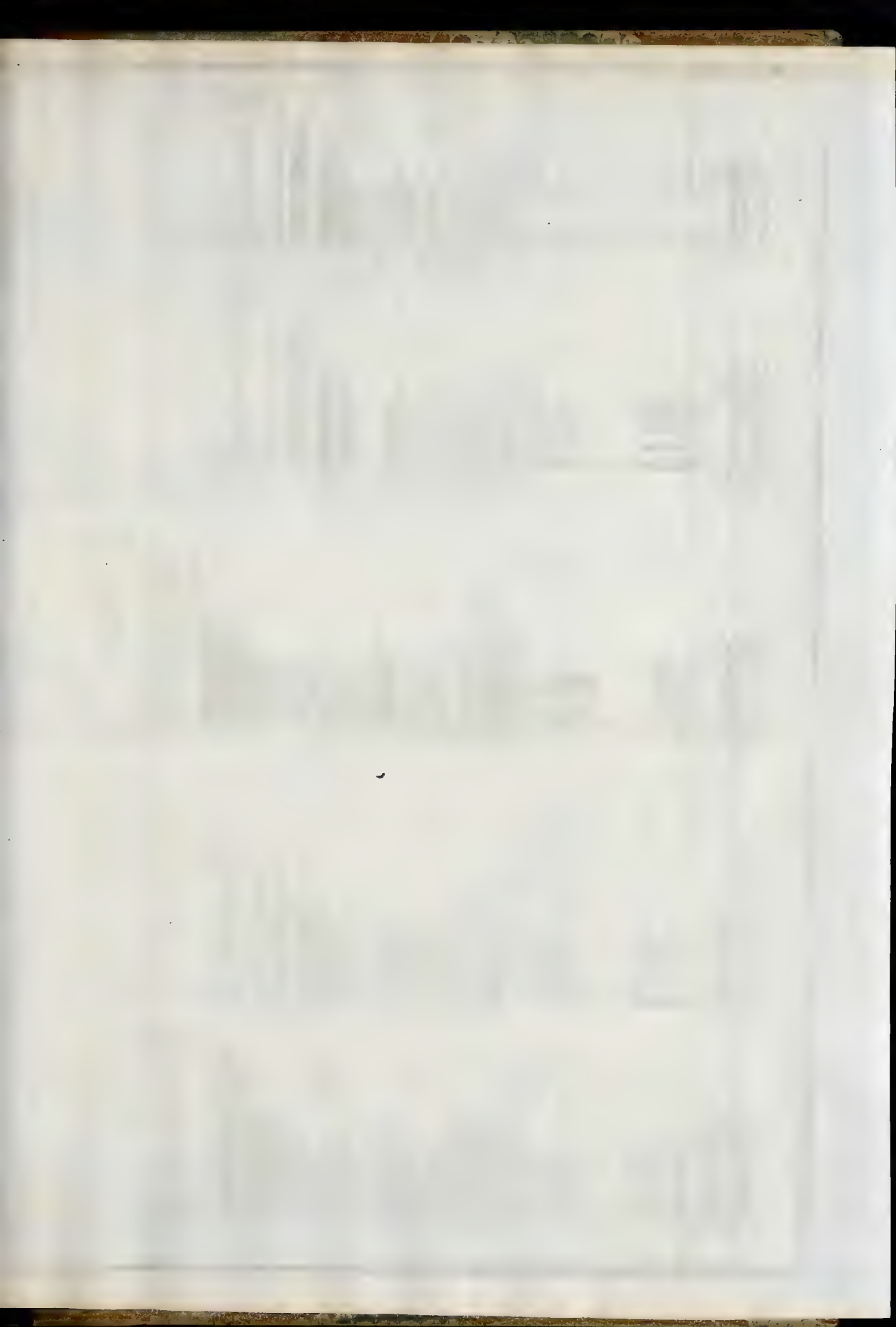
D. BARBARO.

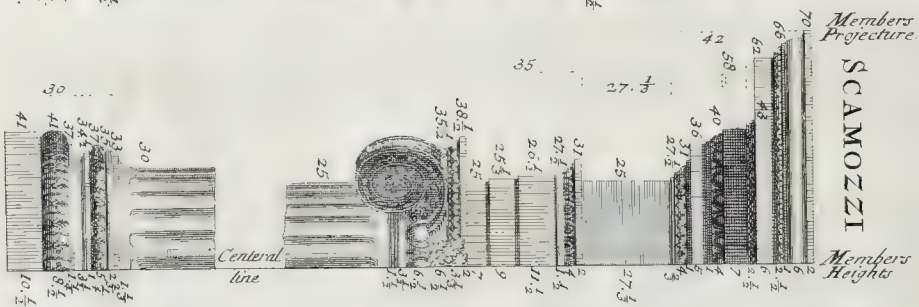
The Columns with their Base and Capitals 9 Diam.

PERRAULT.

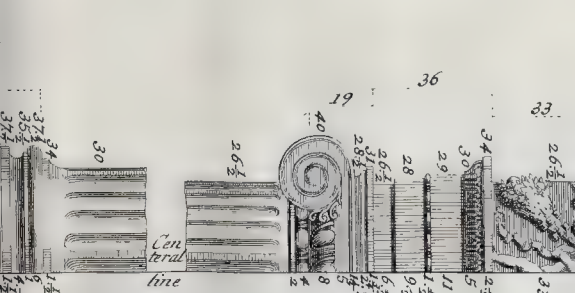
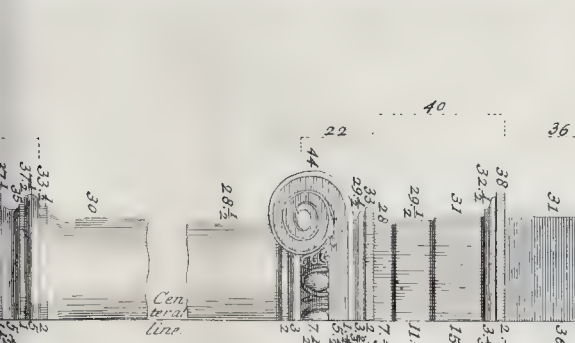
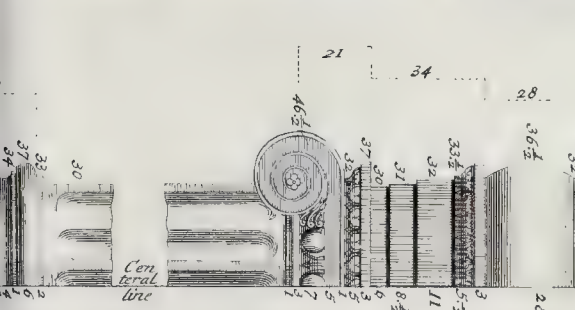
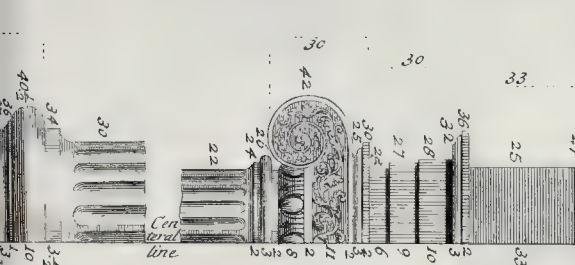
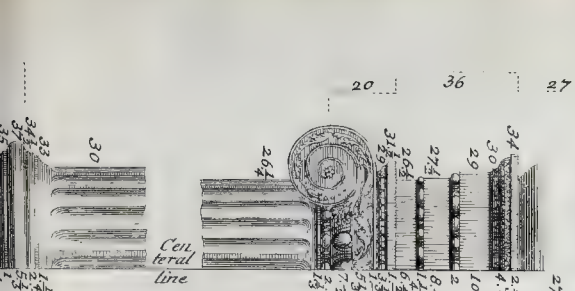
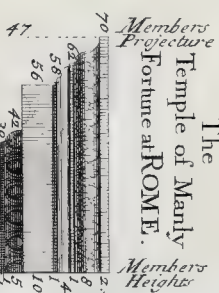
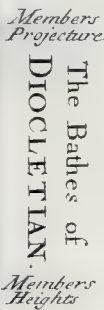








Geometrical Elevations of ^eIONICK Base, Capitals, and Entablatures according to the Proportions of

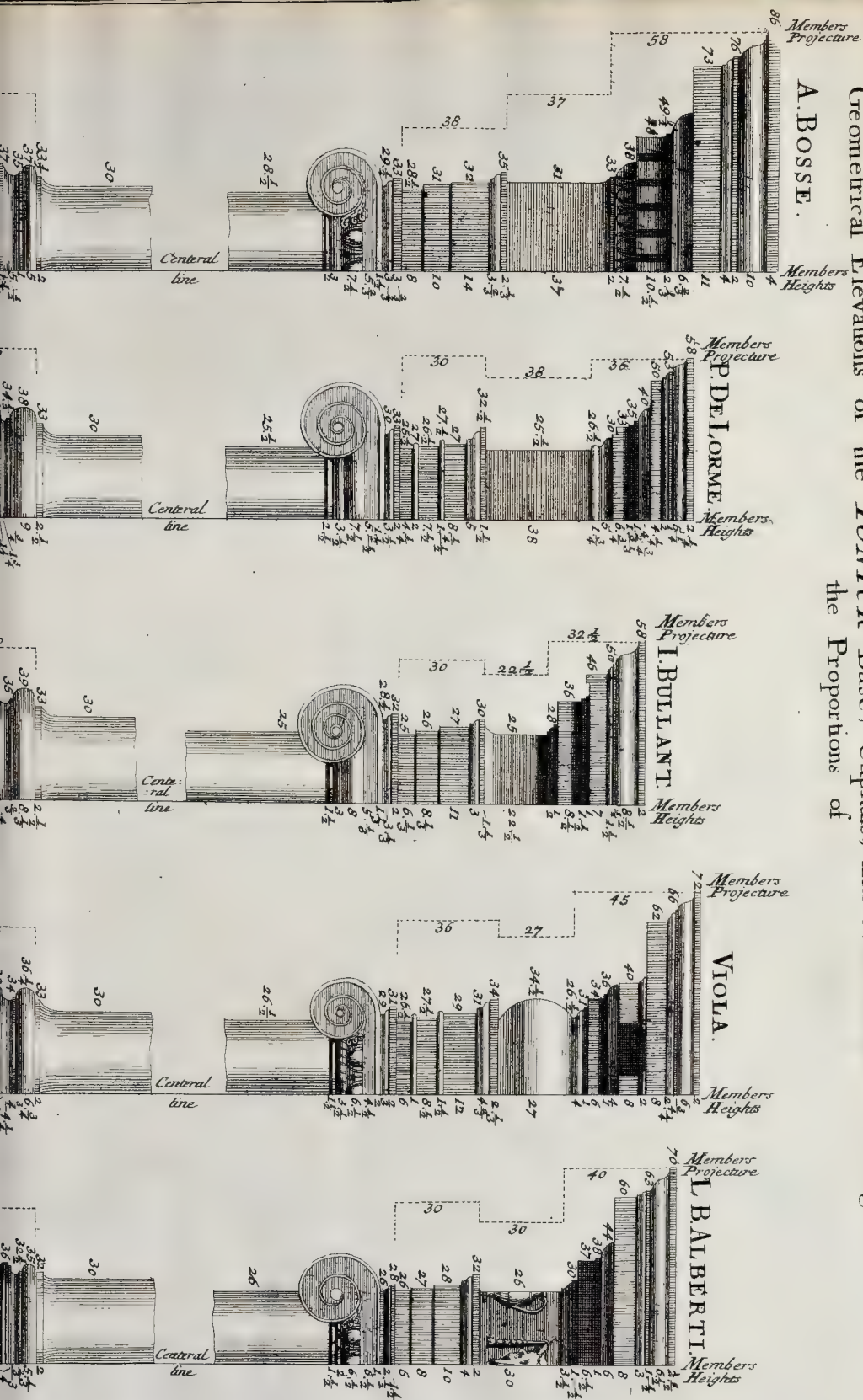






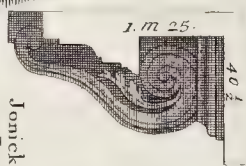
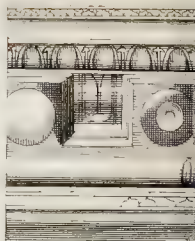
Geometrical Elevations of the *IONICK* Base, Capitals, and Entablatures according to
the Proportions of

A. BOSSE.

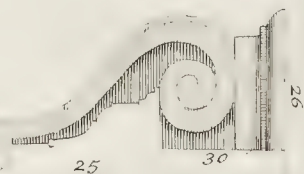
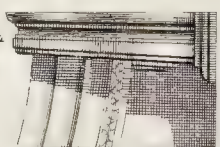




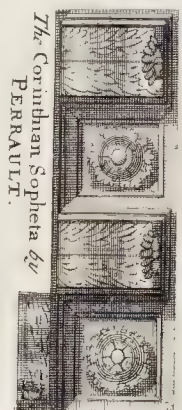
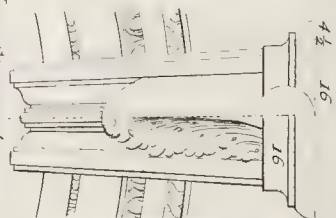




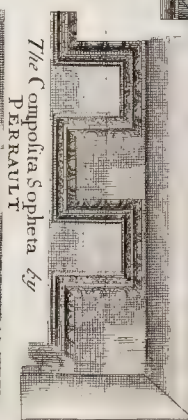
Jonick Key Stones
by LE CLERC.



Corinthian Key Stones by
LE CLERC.



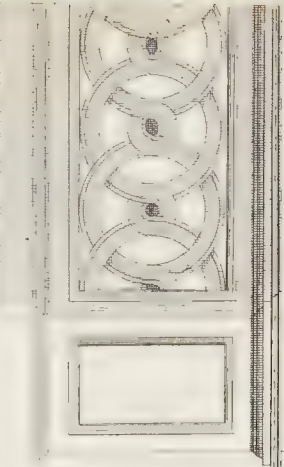
The Corinthian Sopheta by
PERRAULT.



The Composite Sopheta by
PERRAULT.



An Ancient Ornament
used instead of Balustrades.

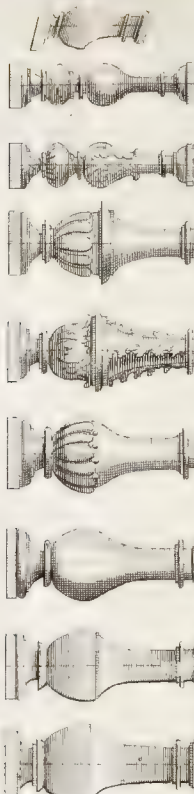


Balustrades
by LE CLERC.

Doric.

Doric.

Tuscan.

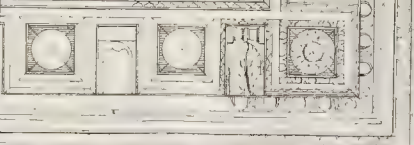


The Dorick Sopheta by
LE CLERC.

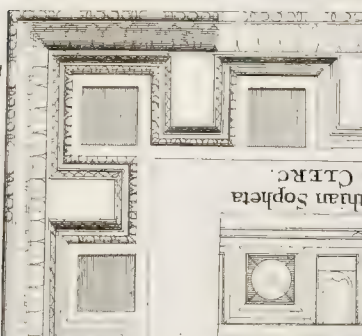
The Jonick Sopheta by
LE CLERC.

The Dorick Sopheta by
LE CLERC.

The Corinthian Sopheta
by LE CLERC.



Roman Sopheta by
LE CLERC.



LE CLERCS Elevations of the

SPANISH Order.

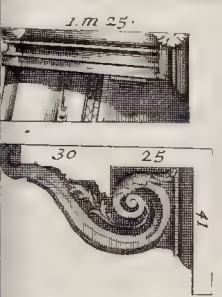
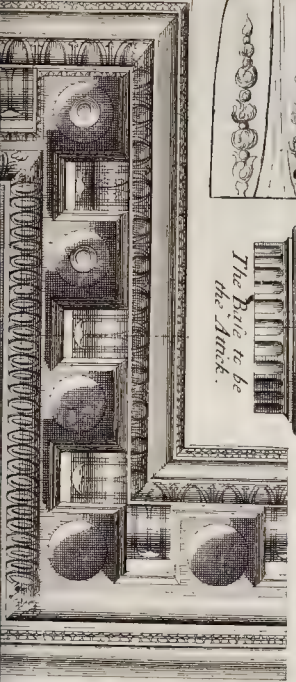
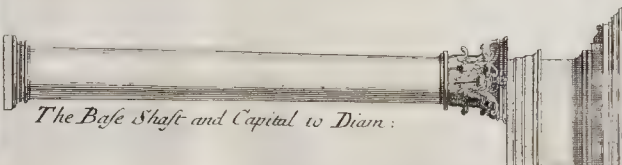
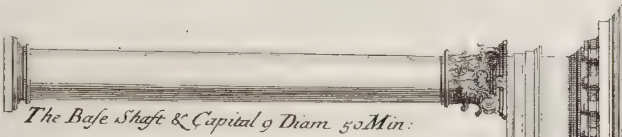
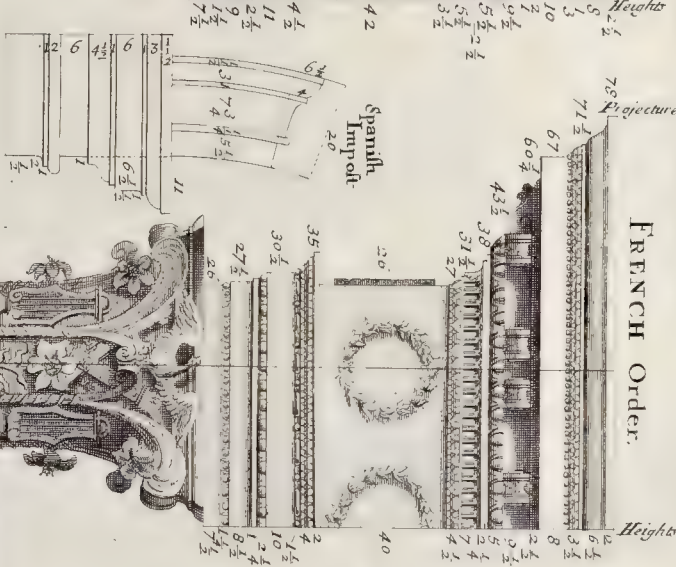
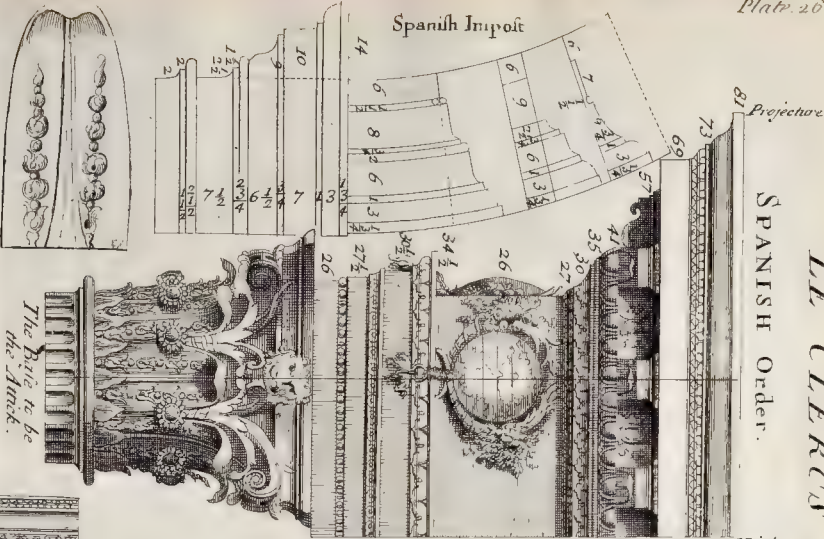
FRENCH Order.

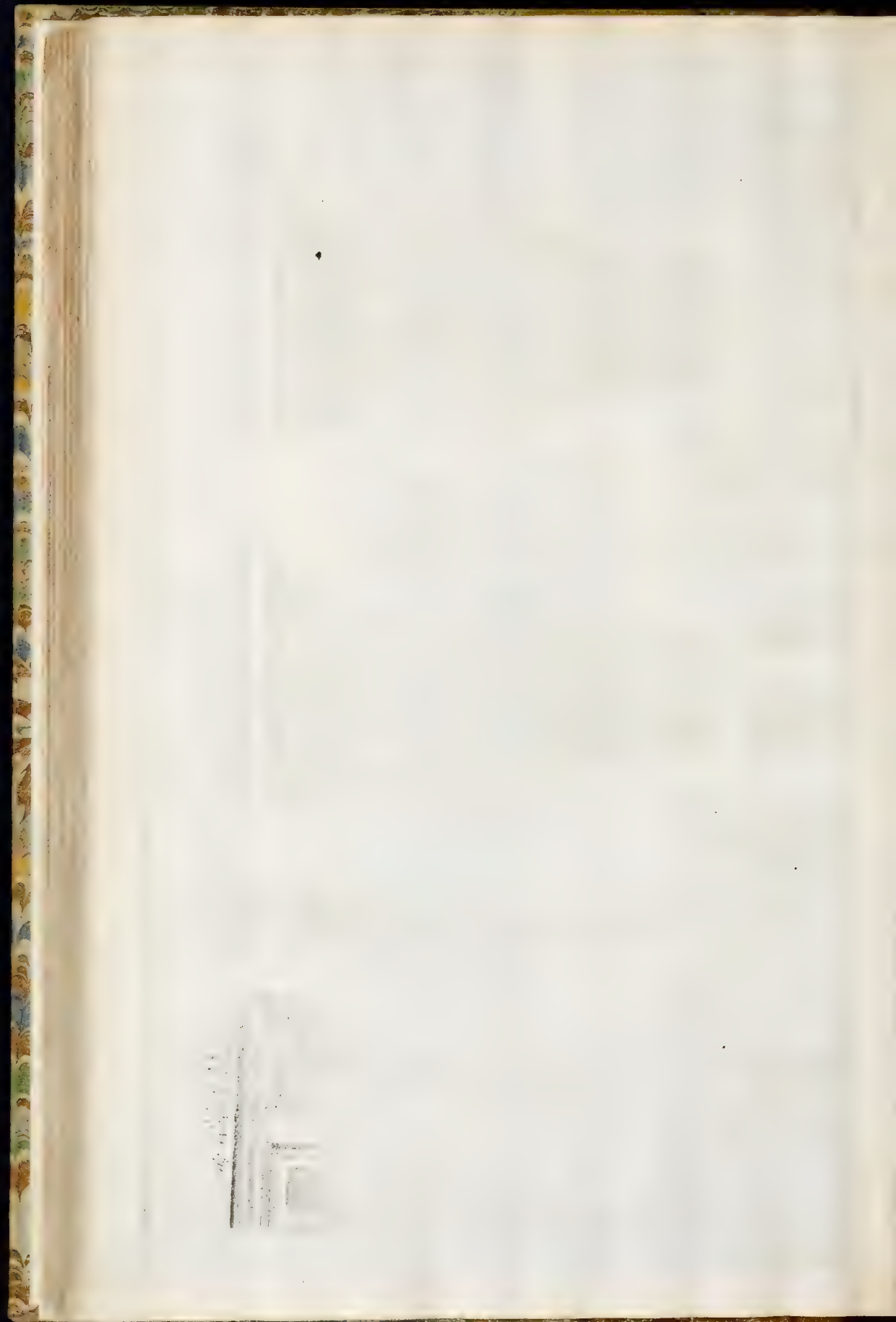
LE CLERCS Profiles of the

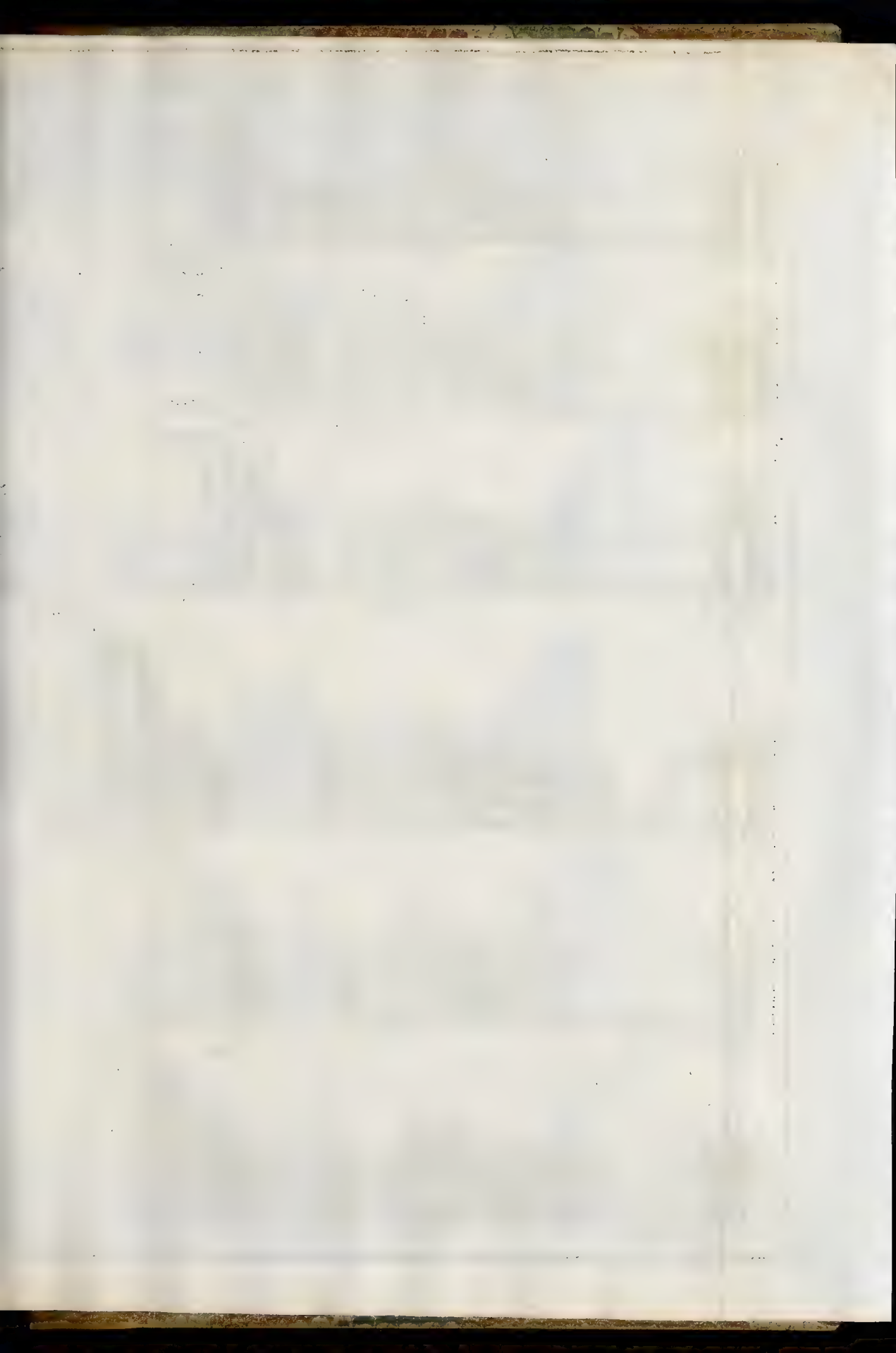
SPANISH Order.

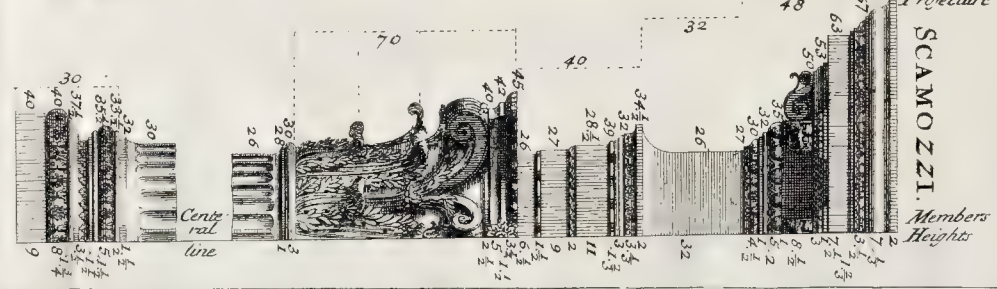
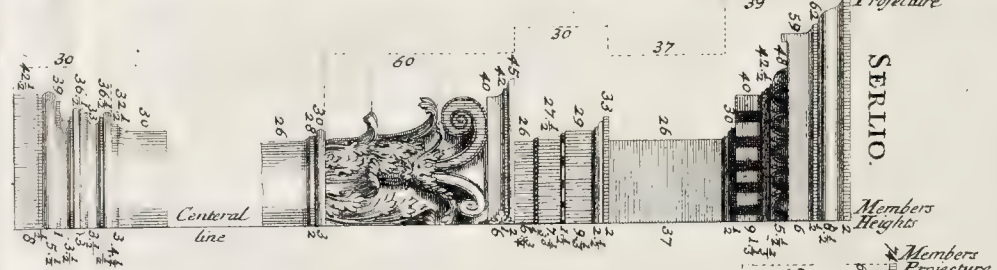
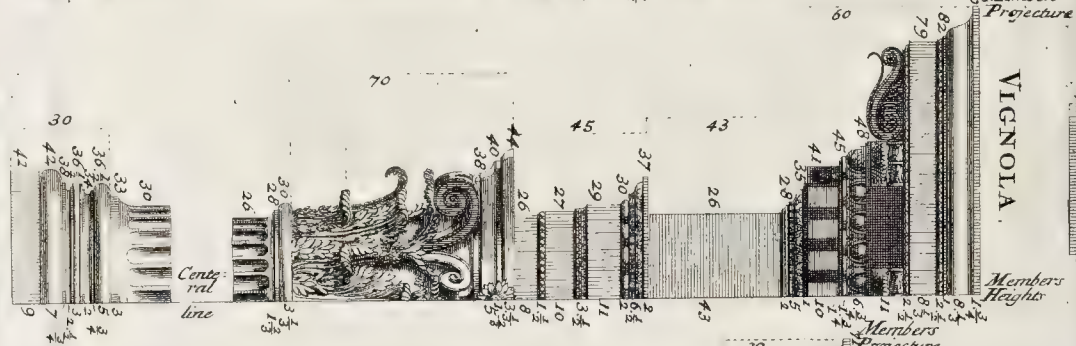
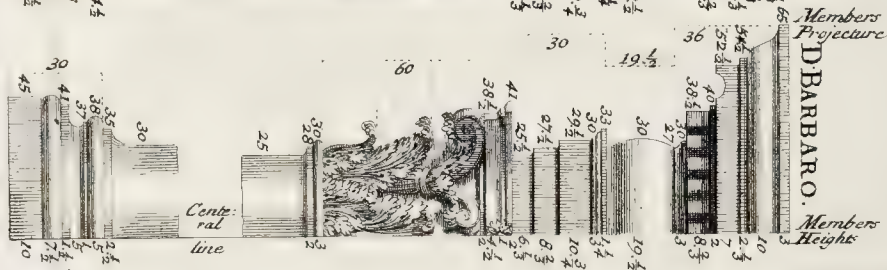
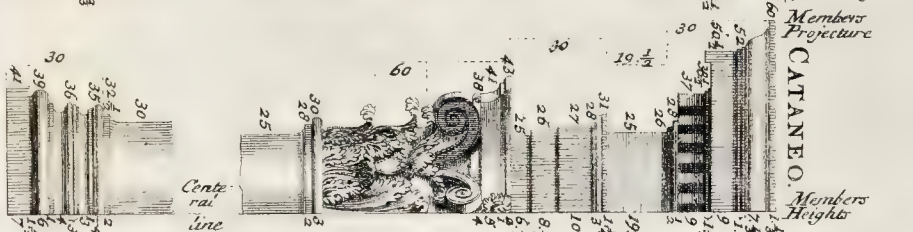
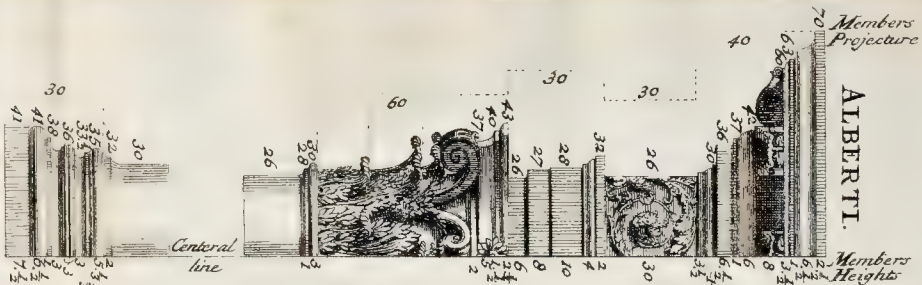
COMPOSITA Order.

CORINTHIAN Order.









Geometrical Elevations of the CORINTHIAN Base, Capitals and Entablatures according to

The Sopheta
of the Cornish at
the Bath of
DIOCLETIAN.

Members Proj.^c

PALLADIO.

Members Heights

The Temple of
JERUSALEM.

Members Proj.^c

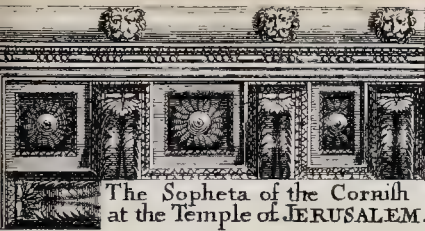
The Frontpiece
of Neron at ROME.

Members H.

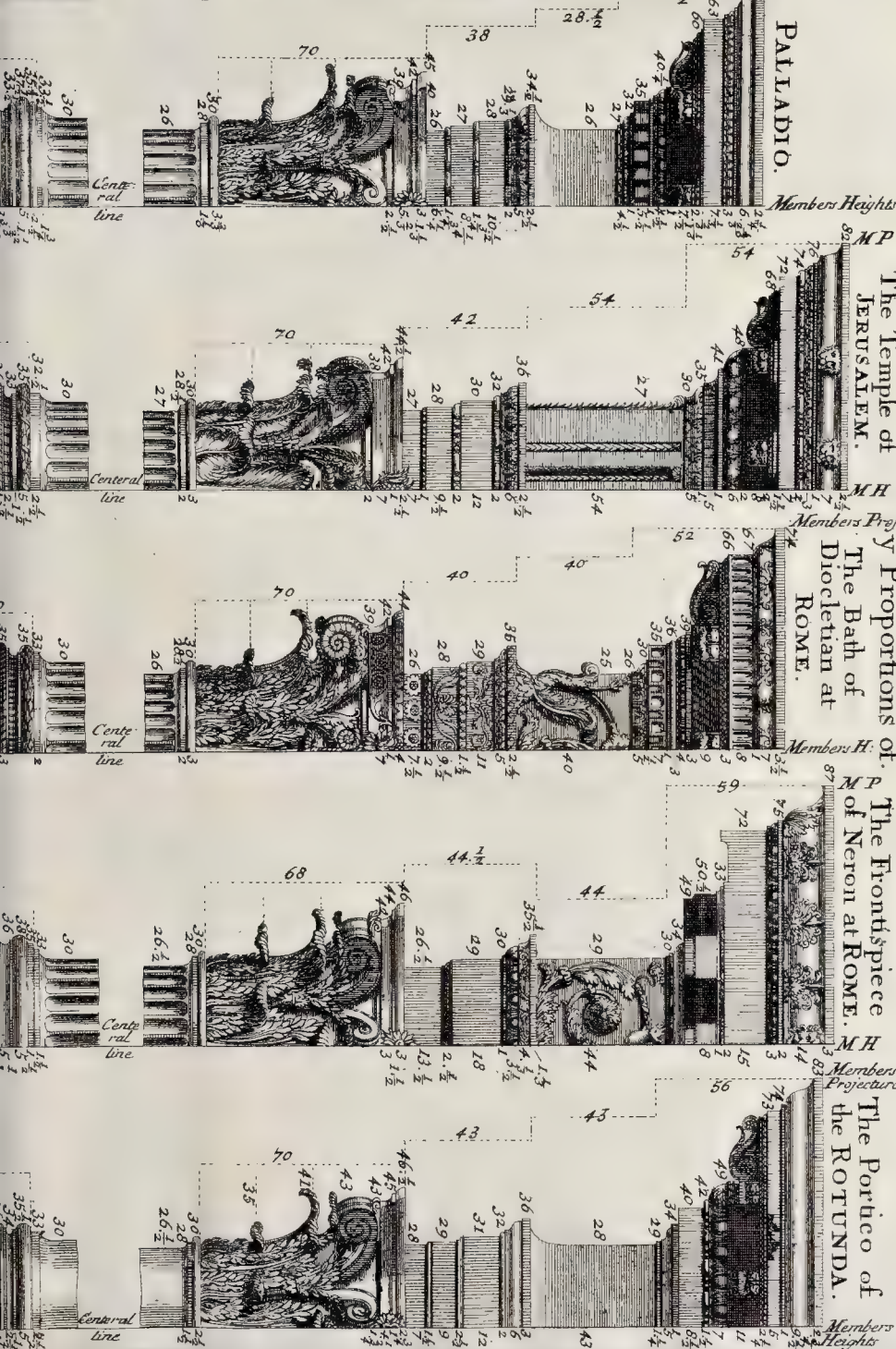
The Portico of
the ROTUNDA.

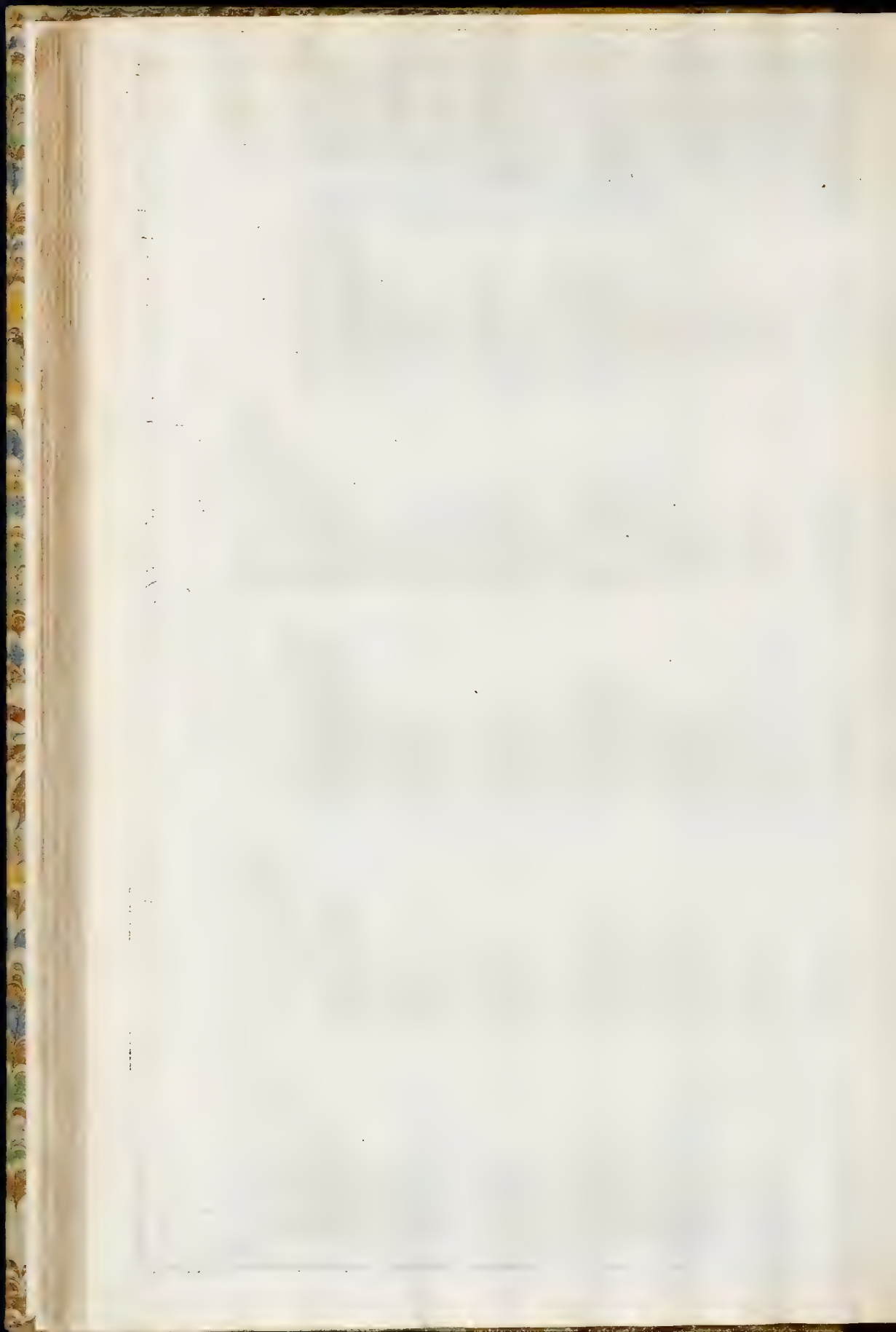
Members Projecture

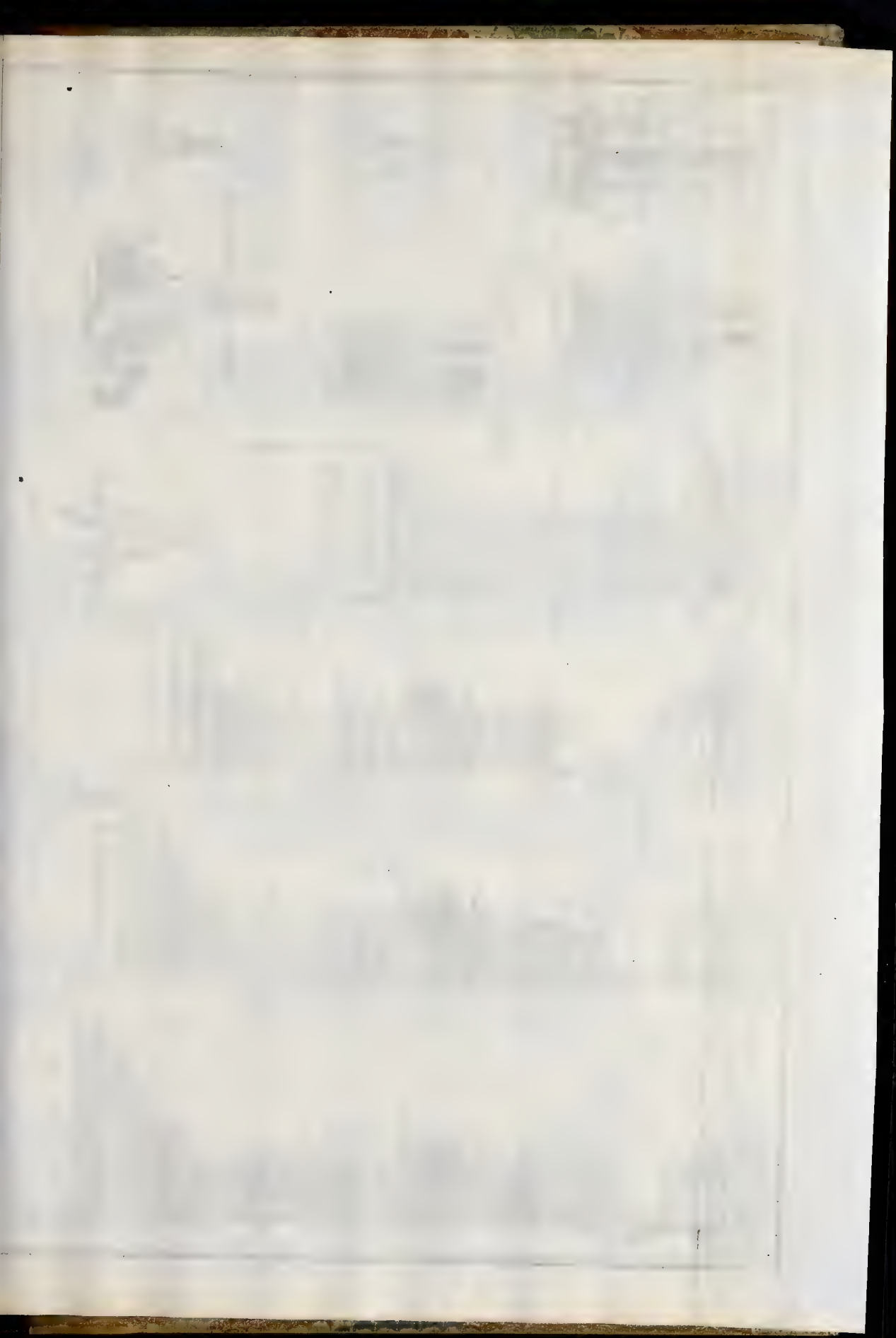
Members Heights



The Sopheta of the Cornish
at the Temple of JERUSALEM.

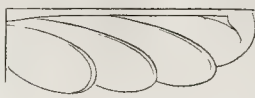
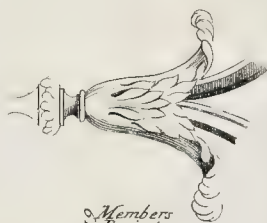
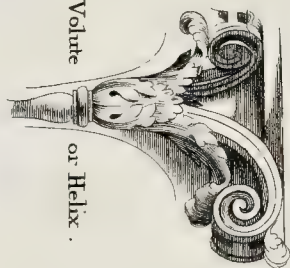




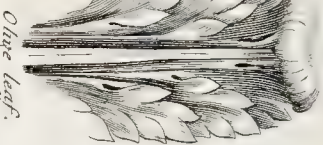
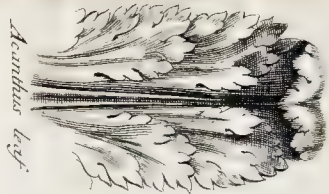
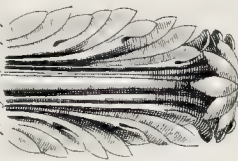




The Volute
or Helix.



A Laurel leaf of the Capital
in the Temple of Vesta at ROME.



Acanthus leaf.

Olive leaf.



Geometrical Elevations of the CORINTHIAN Base, Capitals, and Entablatures according to the Proportions of Plate XVIII.

A. BOSSE.



The Rose of the Abacus of the Capital in the Pantheon in the Temple of Trajan, of Jupiter, of Mars the Reverend, in the Baths of Diocletian, & the Market of Nerva.

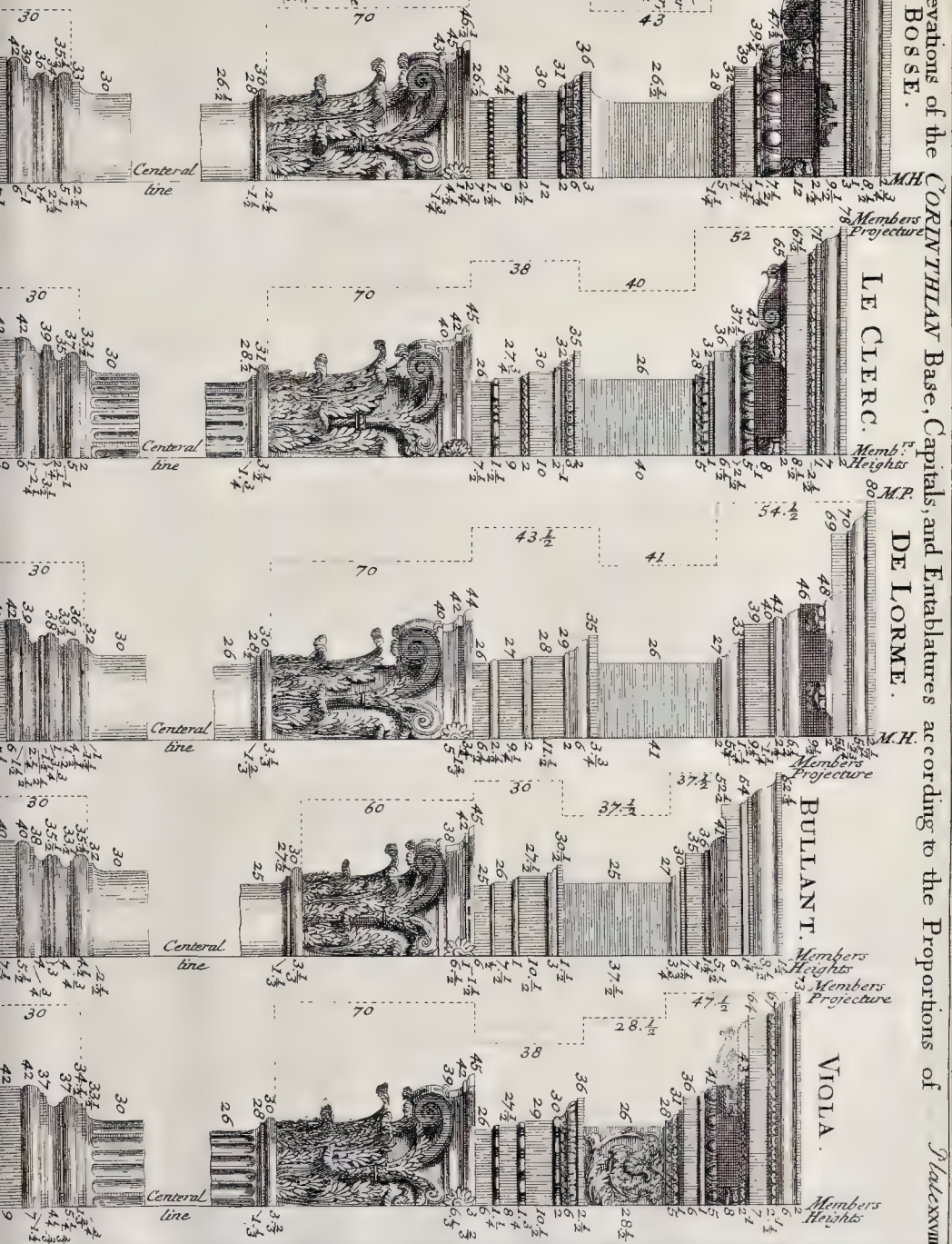


The Rose of the Abacus of the Capital in the Temple of Venus which is placed in the library of our Lord of wheat, instead of a light tail, as above.

The Rose of the Abacus of the Capital of the three Columns of Campo Vaccino, which is cut with leaves of Acanthus with a Pomgranate hanging down in the middle.



The Flower of the Abacus in the Basilica of Antoninus.









An Oblique view of the Acanthus leaf.

Members Projecture

LECLERC'S Roman Order.

Members Heights



An Oblique view of the Rose in the Abacus of the Capital.

PERRAULT.

Members Heights

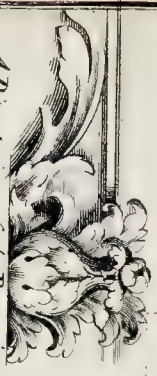
MP

BOSSE.

MH MP

VIGNOLA.

MH



Direct view of the Rose in the Abacus of the Capital.

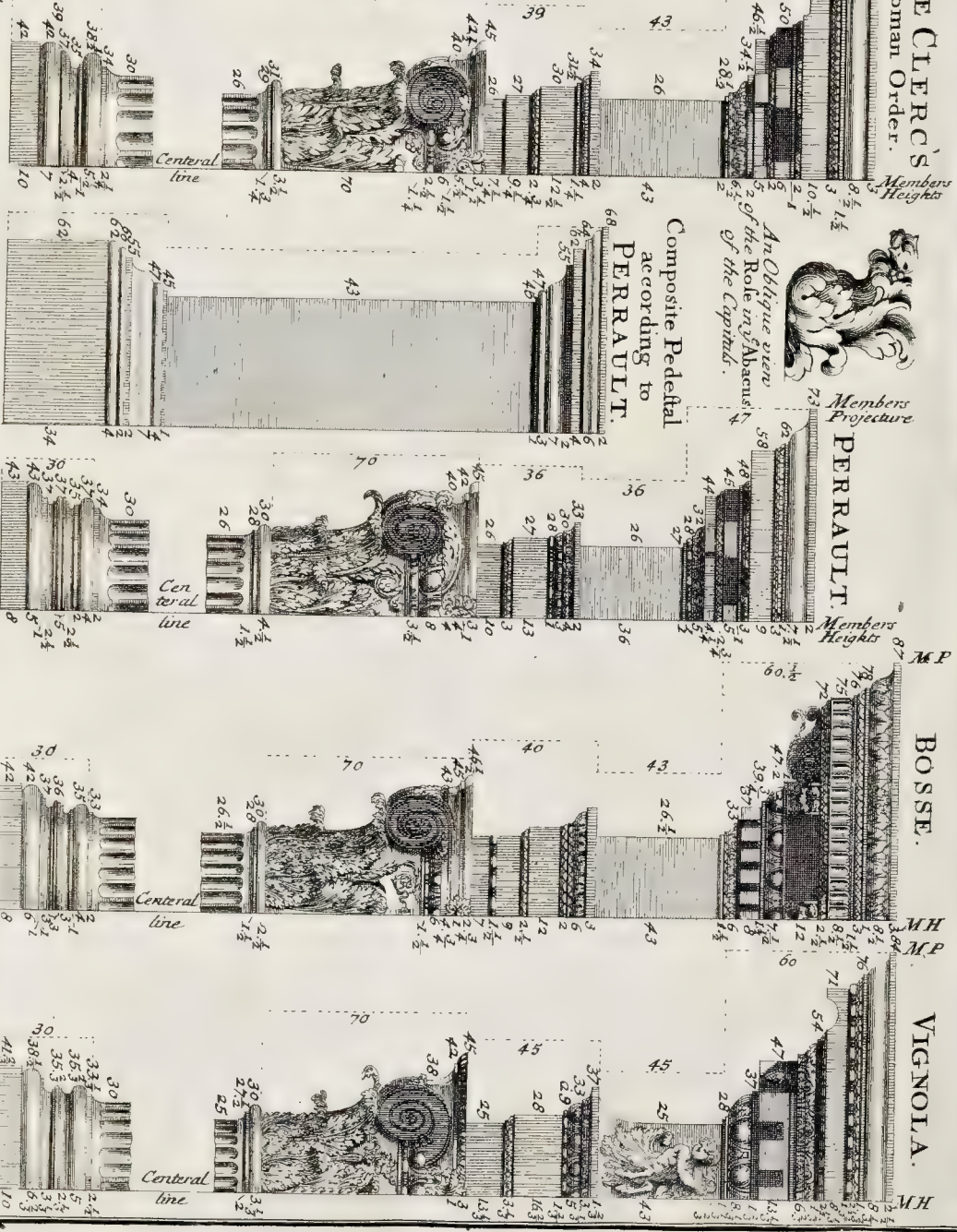


Caulicle terminating in a Rose.

Direct view of the Laurel leaf.



The Acanthus leaves.



Geometrical Elevations of the *COMPOSITA* Base, Capitals and Entablatures according to the

THE ARCH of TITUS at *ROME*.

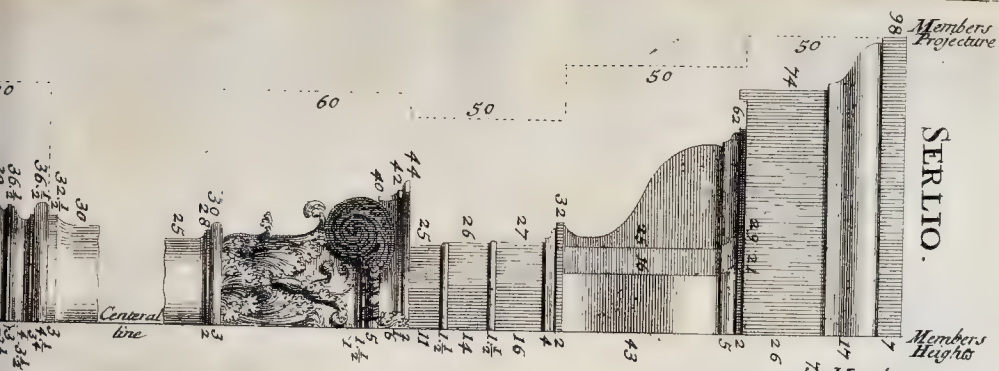
Proportions of

The ARCO de
FIONI at VERONA.

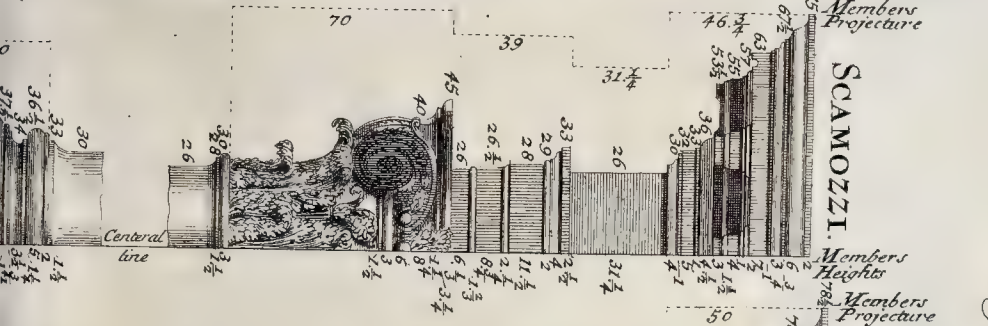
34

Plate XXX

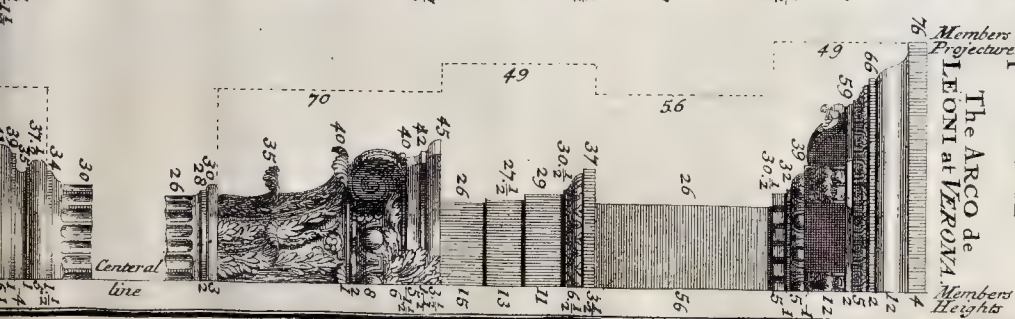
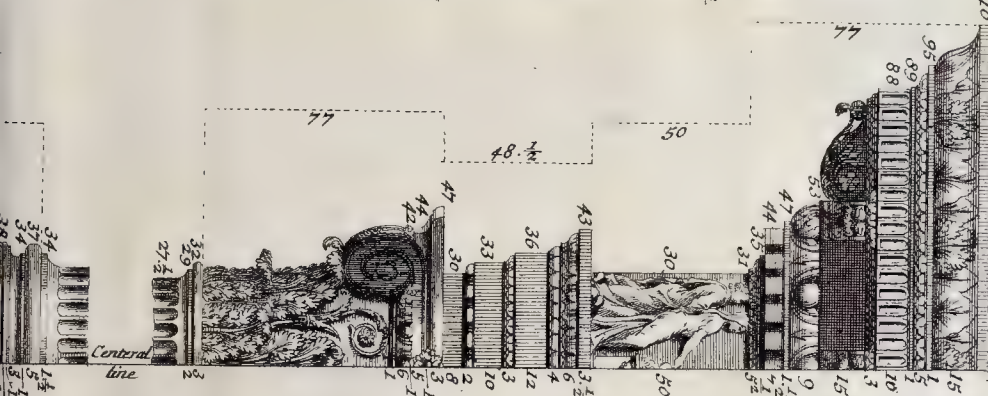
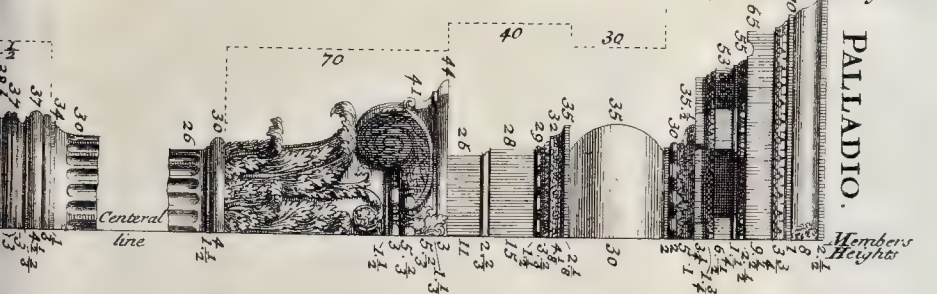
SERTIO.

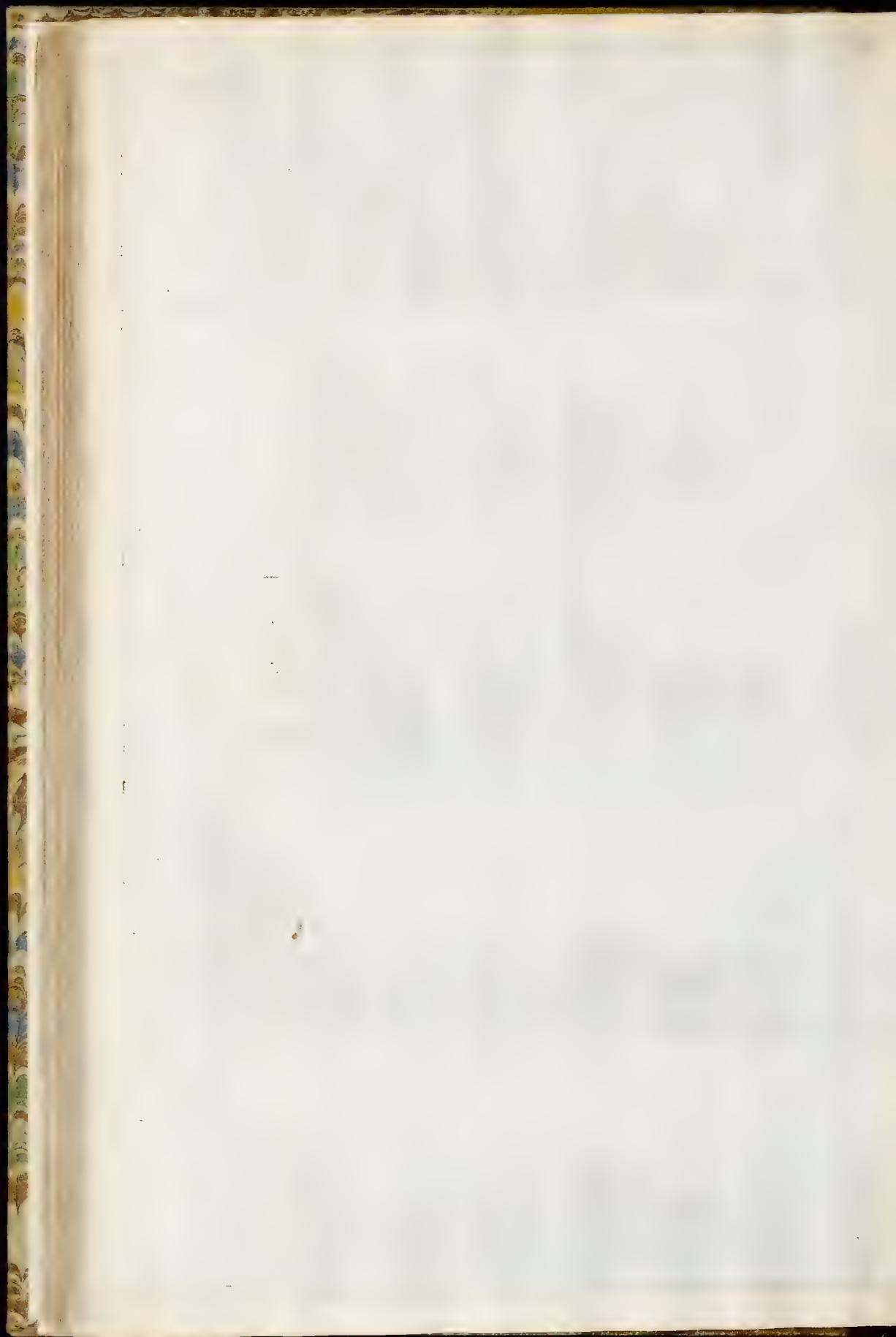


SCAMOZZI



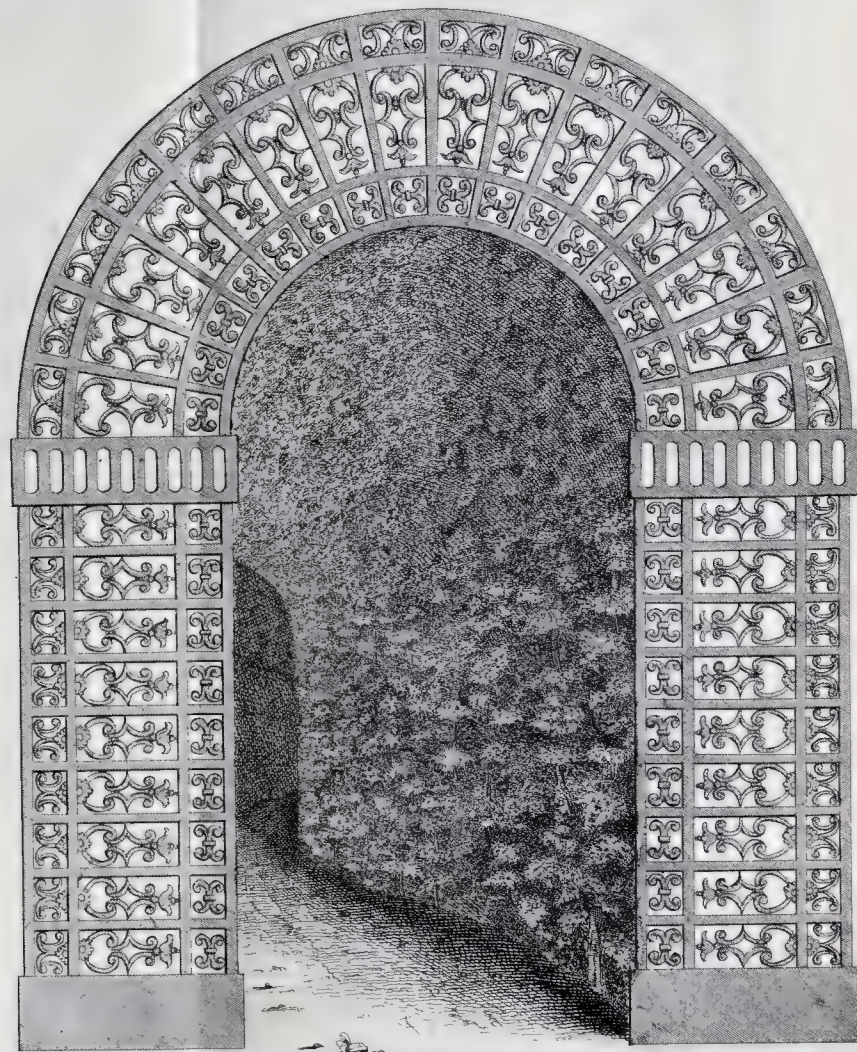
PALTLADIO





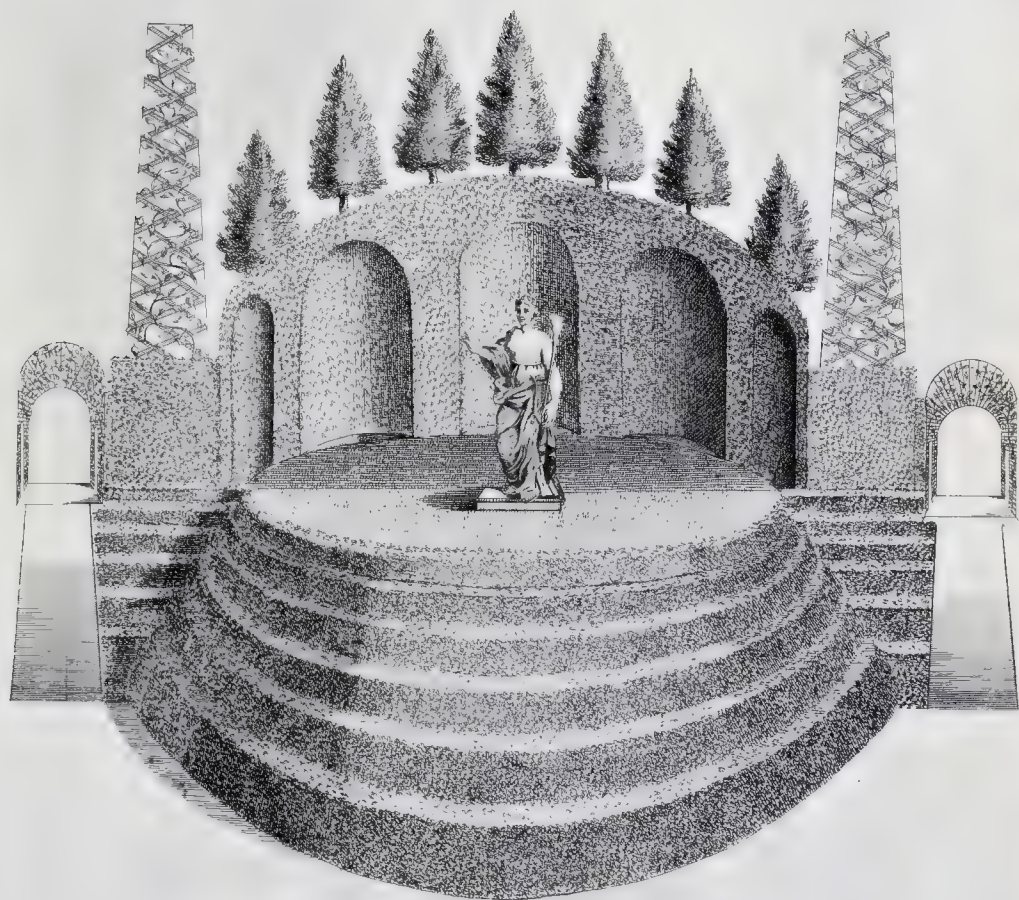






The Frontispiece of an Entrance into a Shady or Artificial Walk

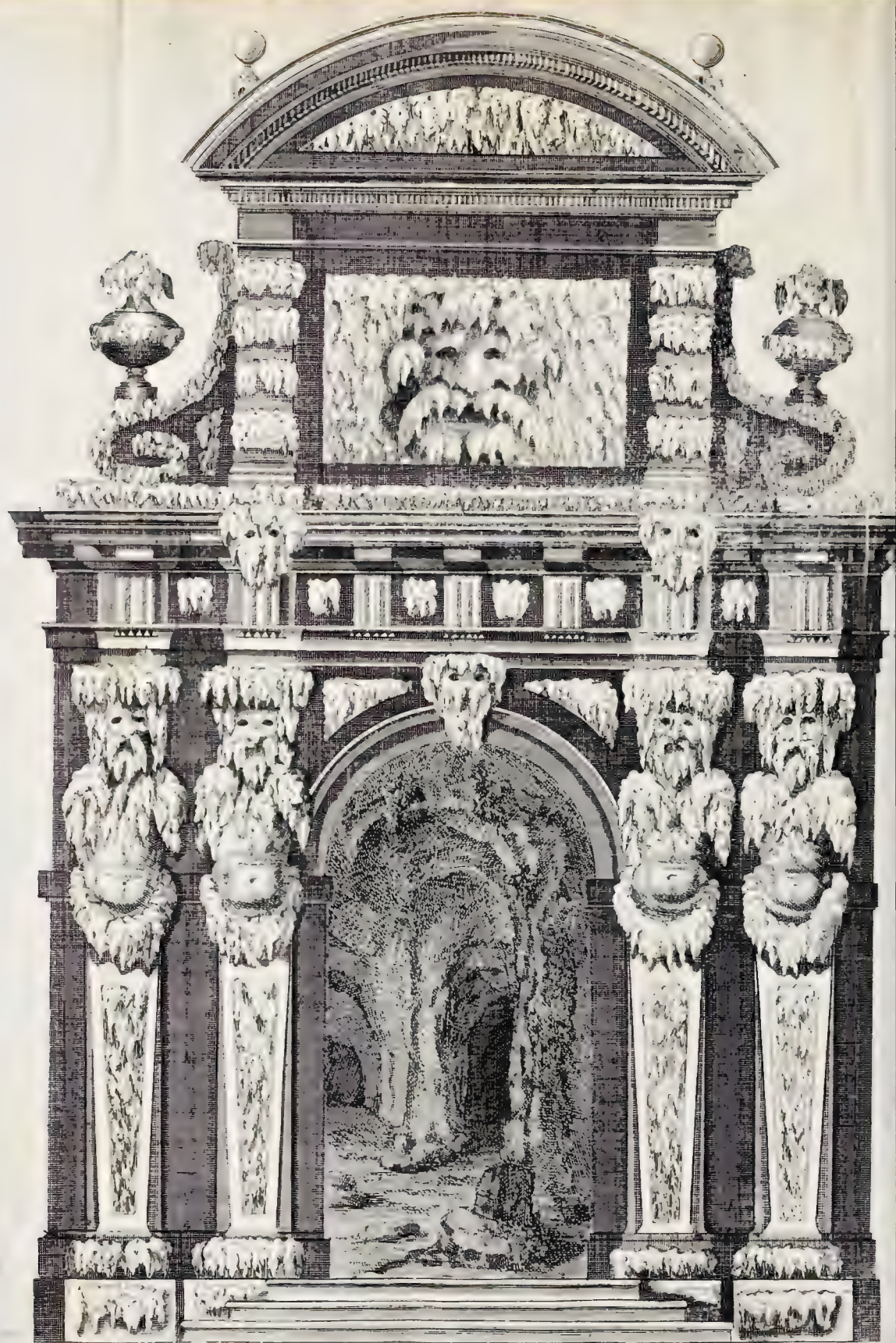




*An Amphitheatrical mount of ever Greens
for y^e Termination of a grand Walk.*





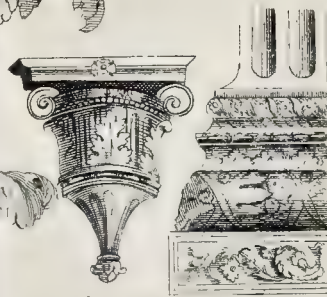
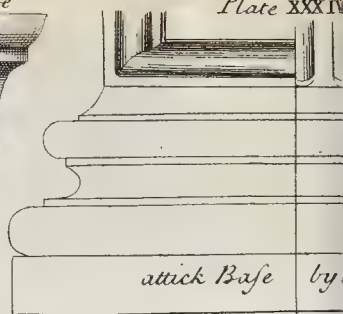




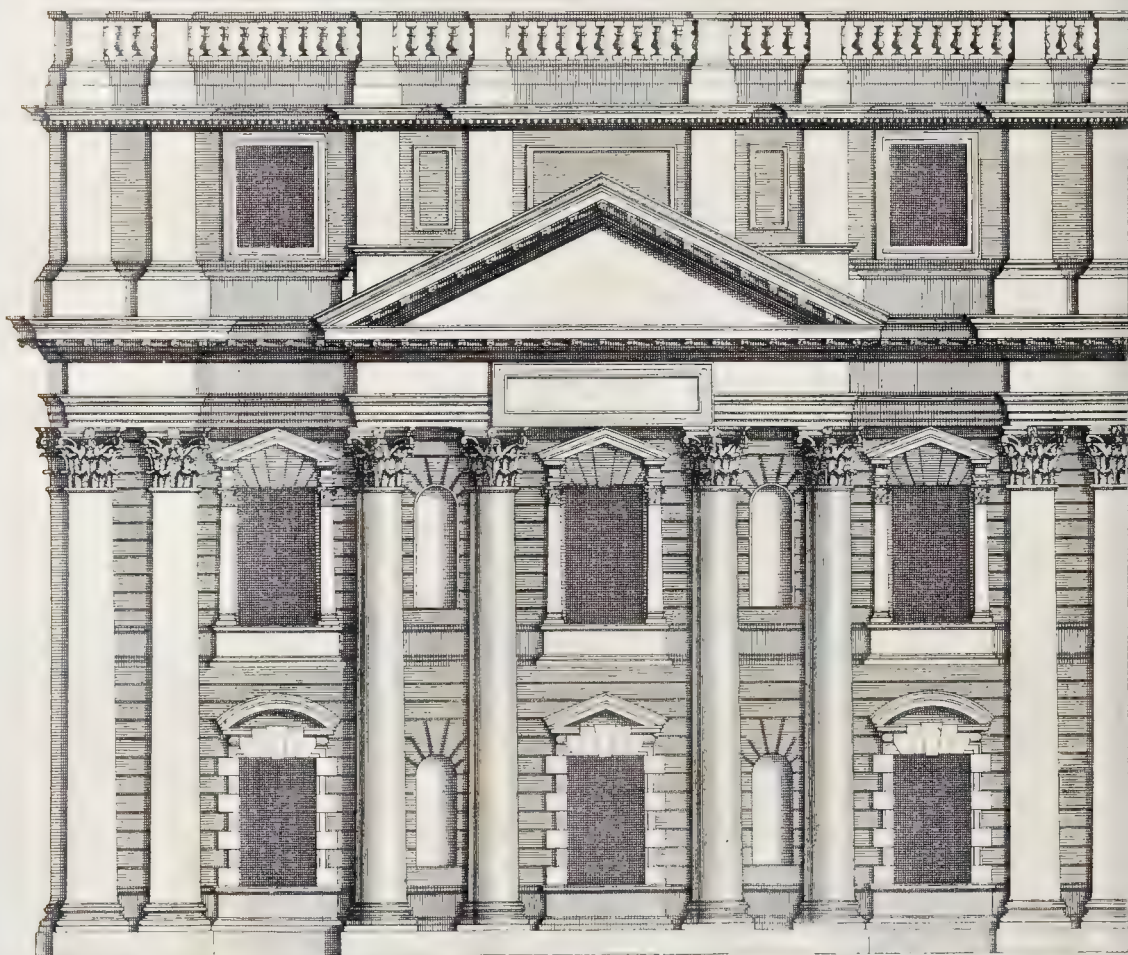
*Geometrical Elevations for Entrances
into Grotto's and Caves.*







from Vitruvius



The Geometrical upright of an noble Structure, Design'd according to, & Grand manner of,

Corinthian Capital with five leaves by A. Bep's



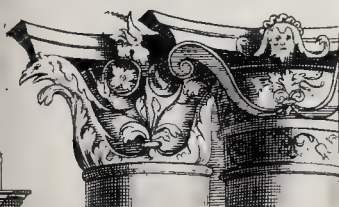
urivius



from Vitruvius



Corinthian Capital with acanthus leaves by Vitruvius



from Vitruvius



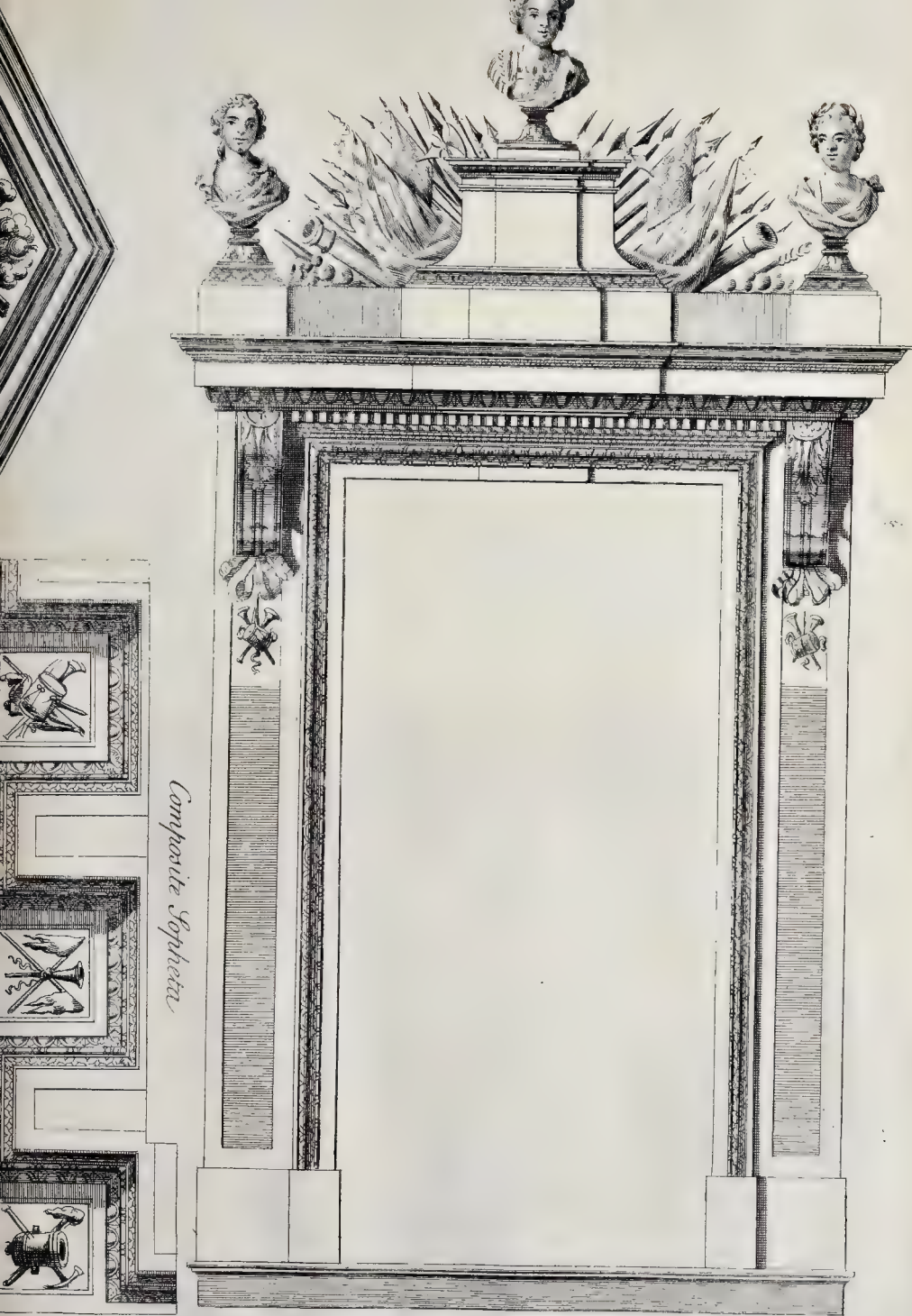
an Enrichment for the Frieze of the Ionic Order





Government according to the wishes of the subjects.

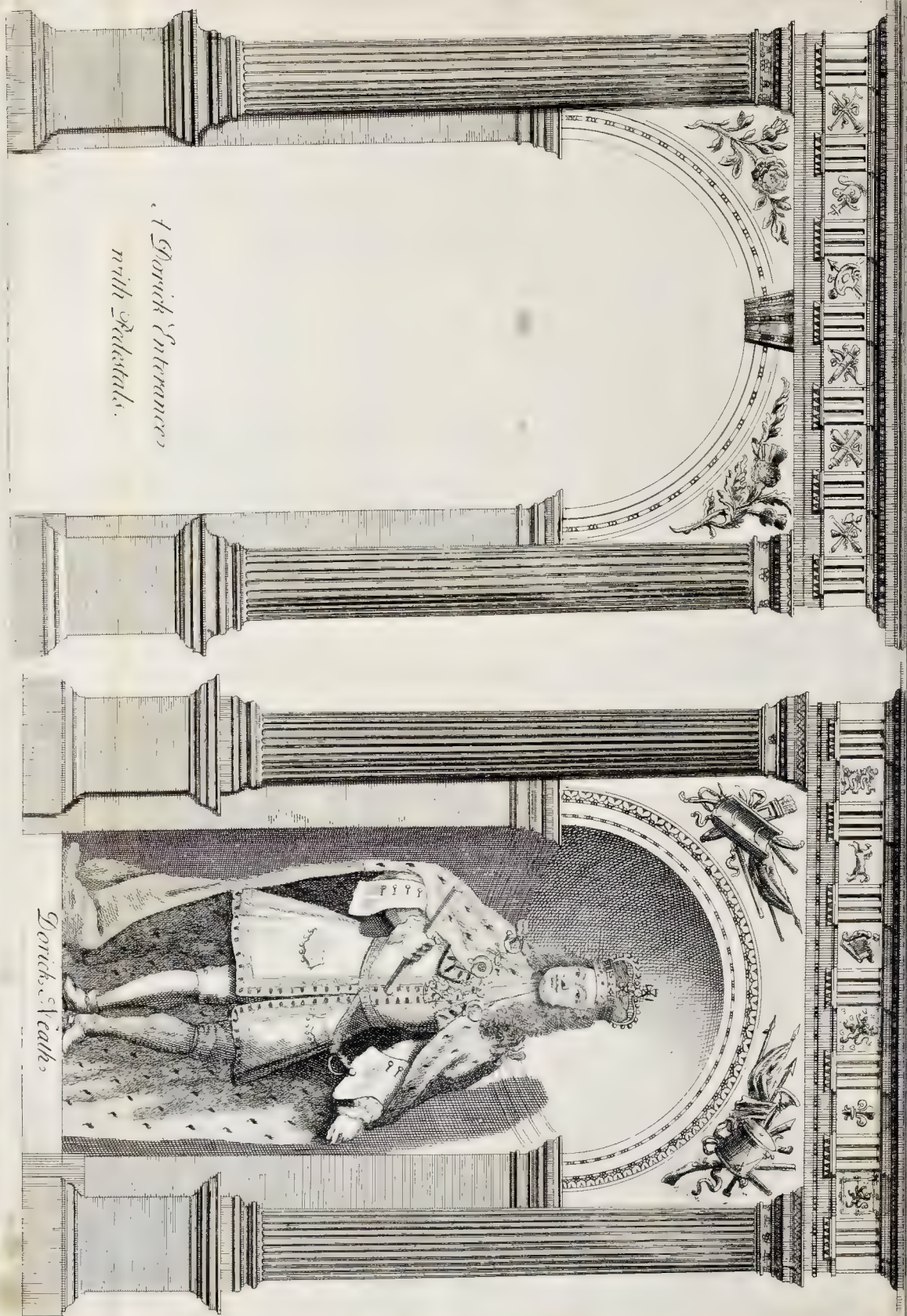




*A Composite Door according to
the Intent.*



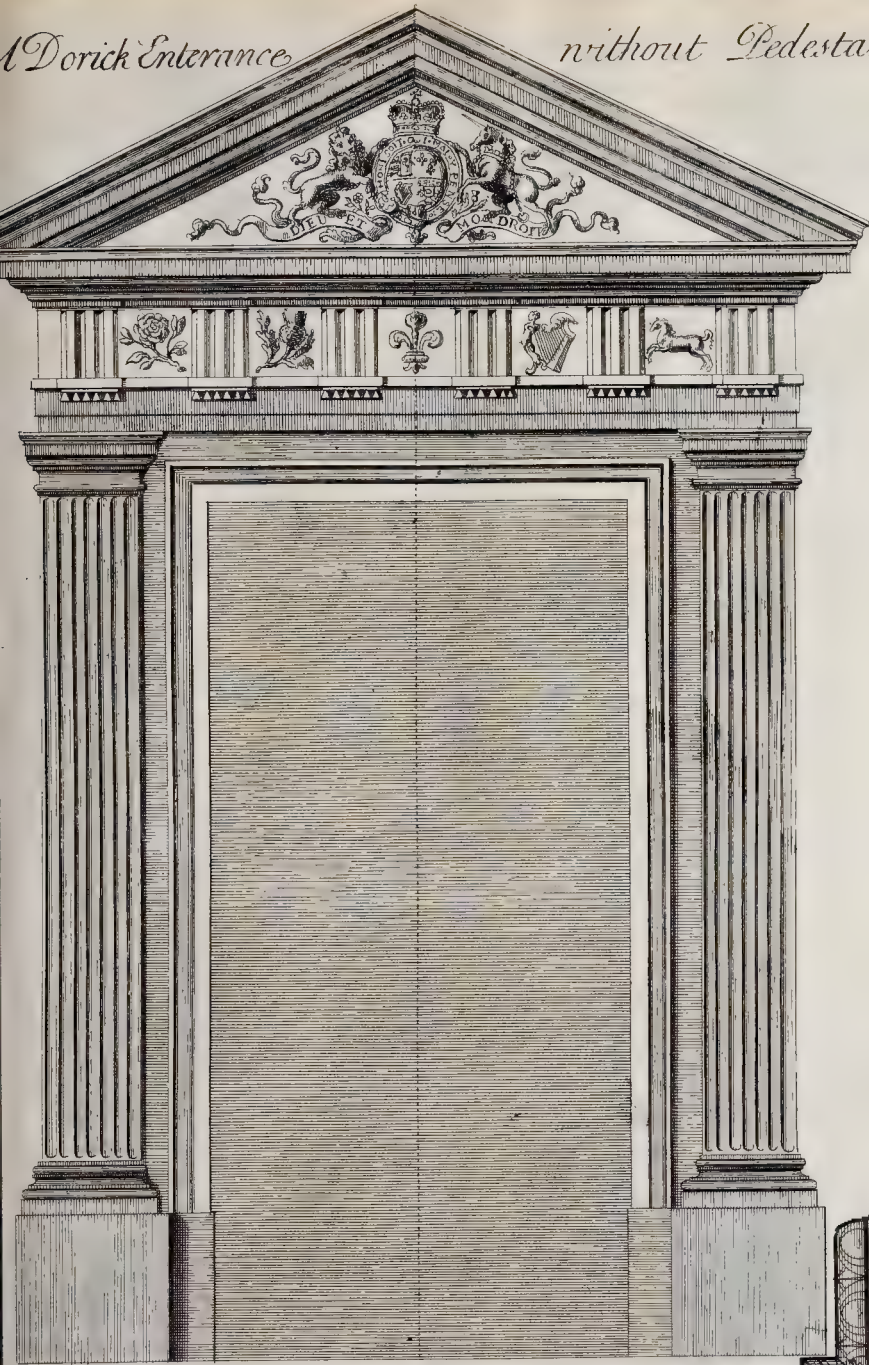




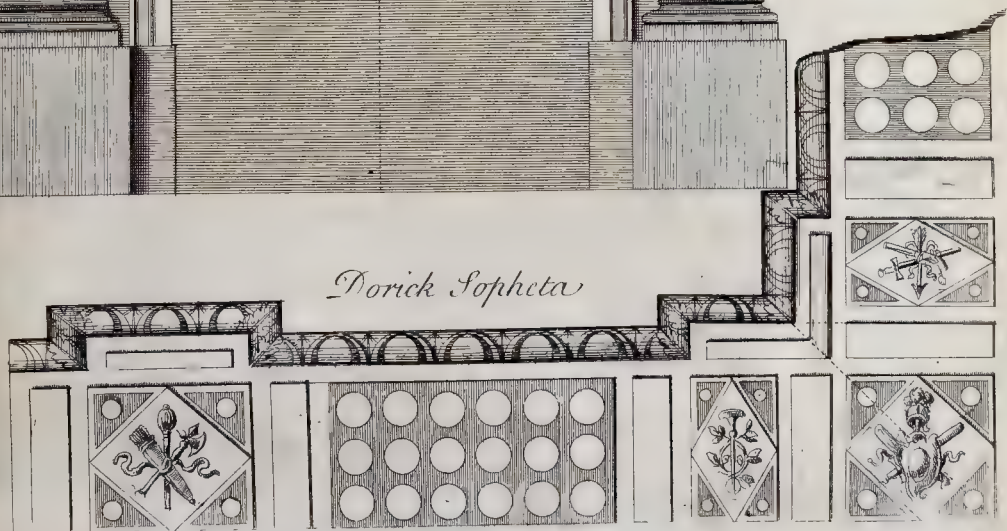
*Doric Entrance
with Pedestals.*

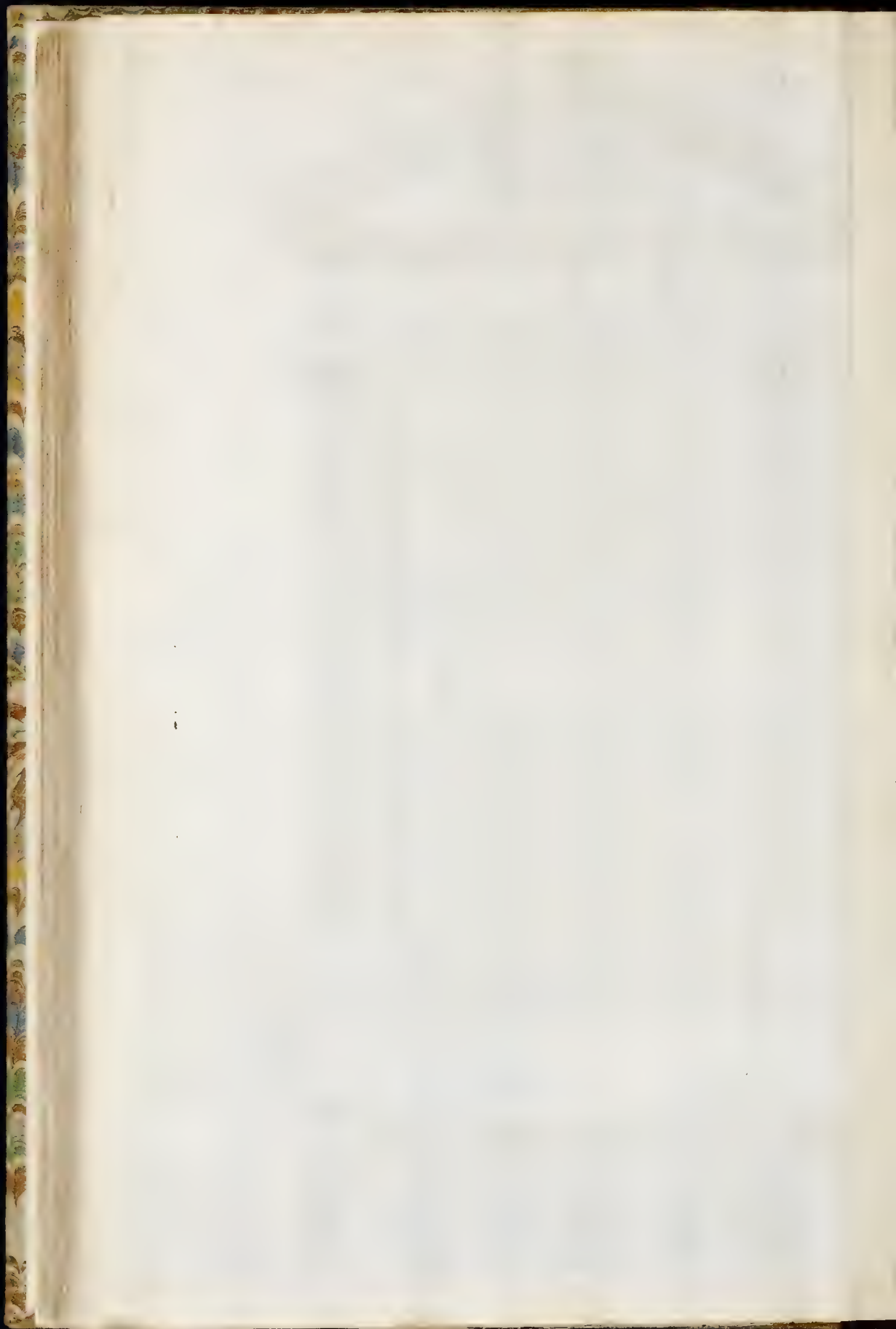
Doric Vault

A Dorick Entrance without Pedestals

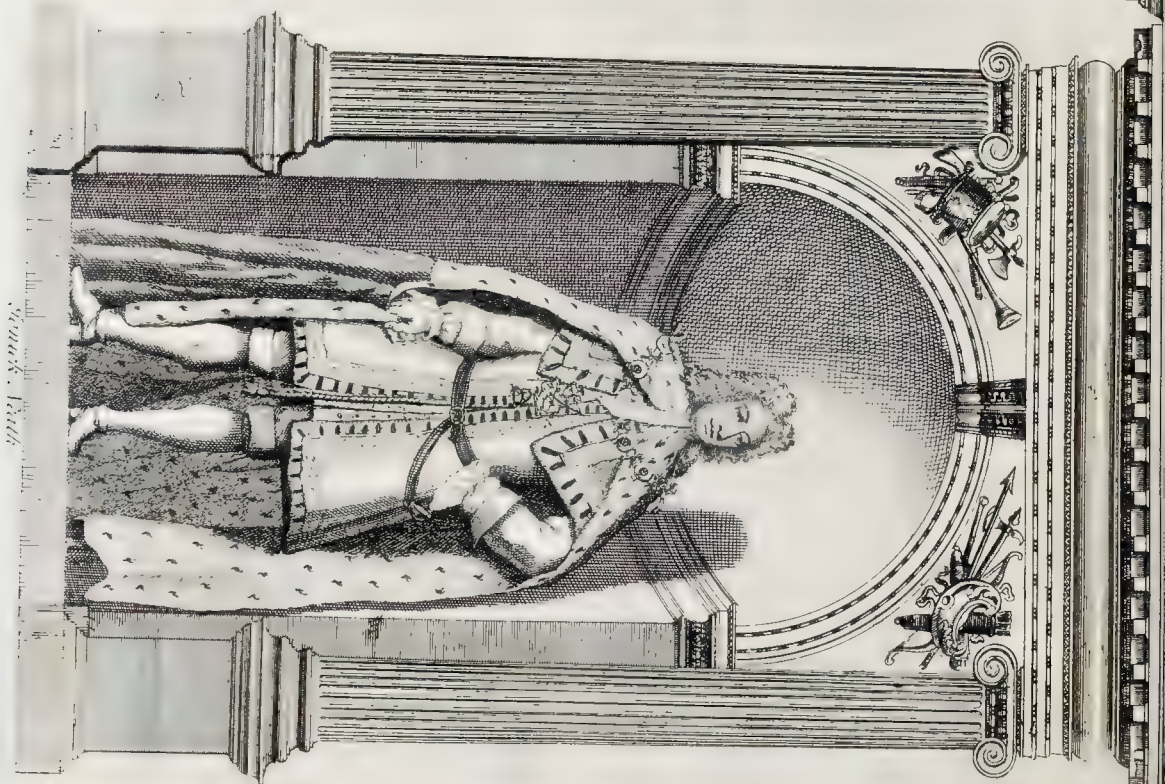
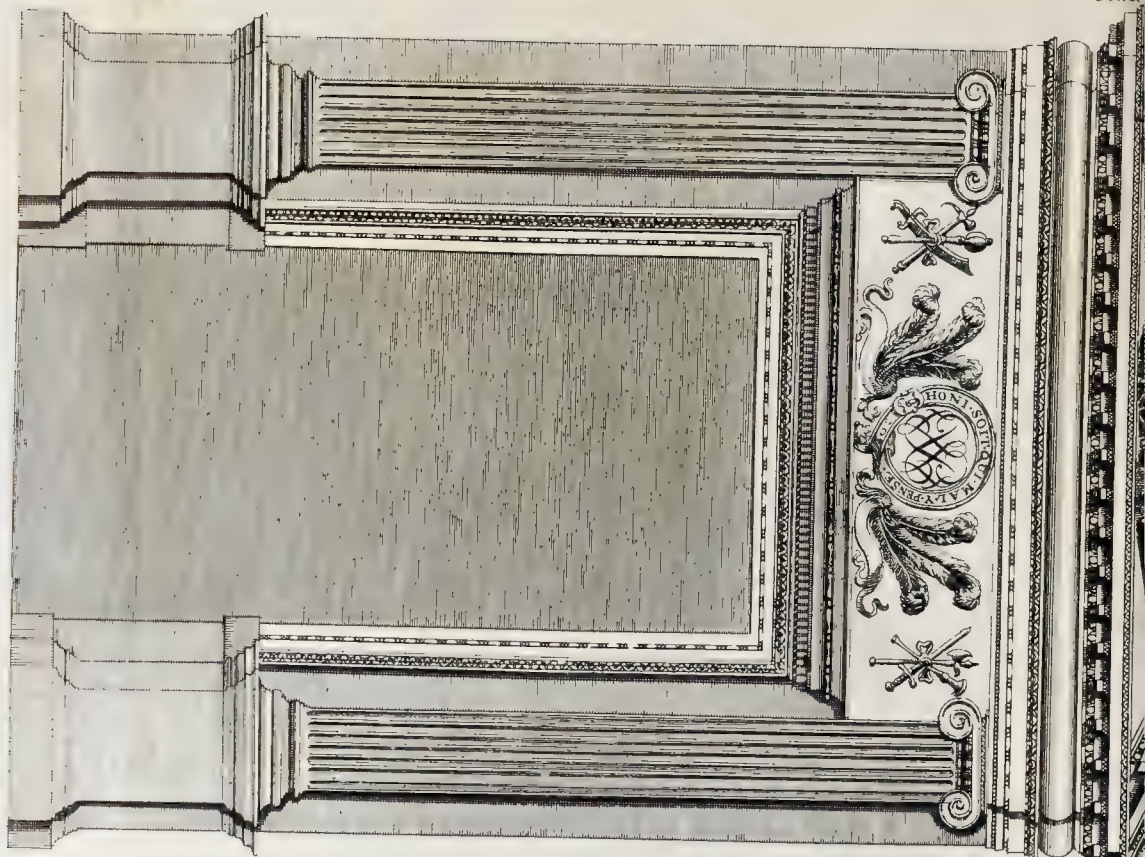


Dorick Sopheta





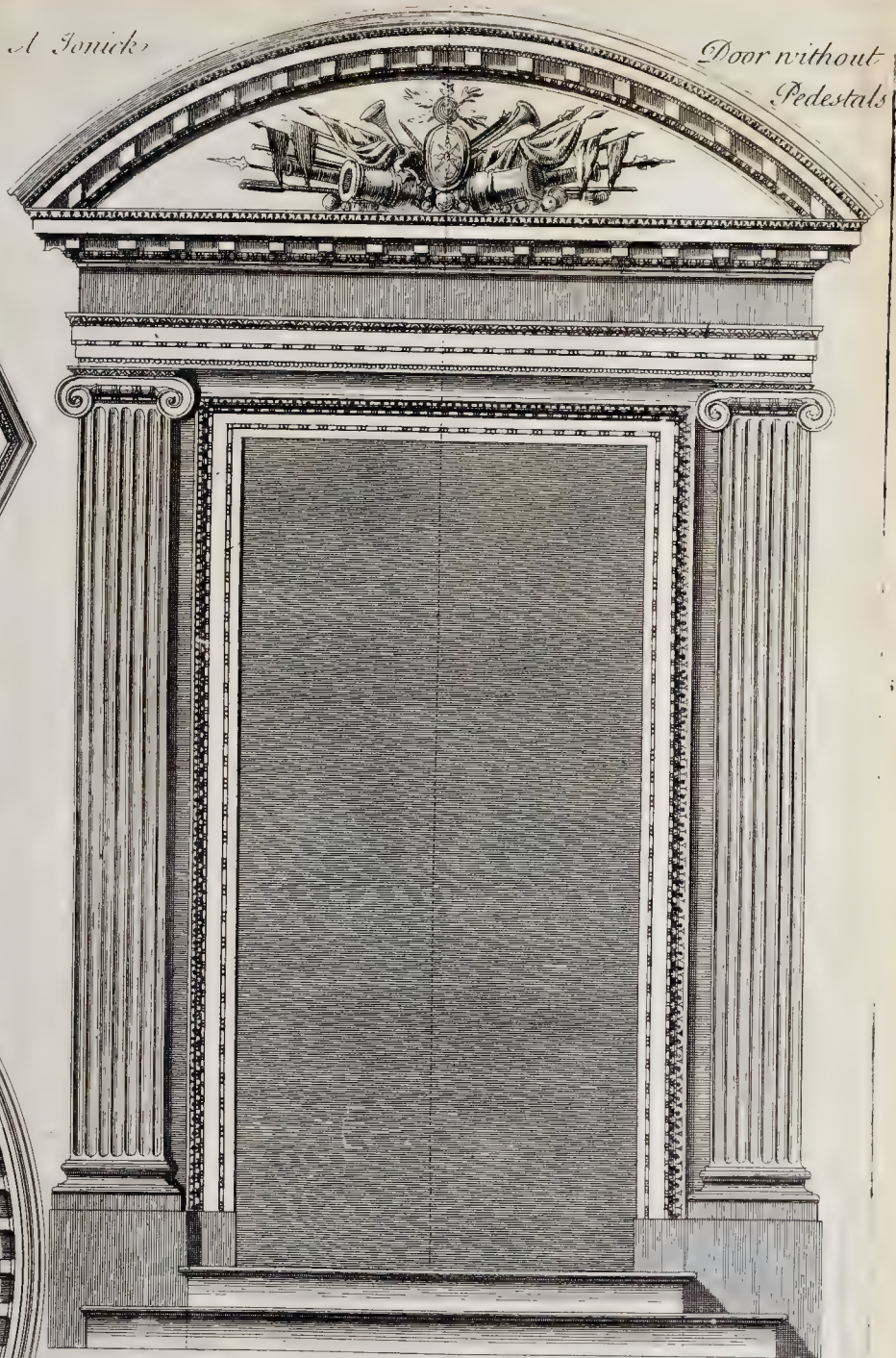




Statue. Plate

A Jonick

Door without
Pedestals

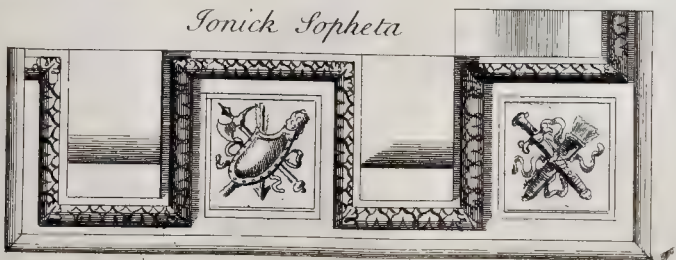


A Jonick

Door with
Pedestals

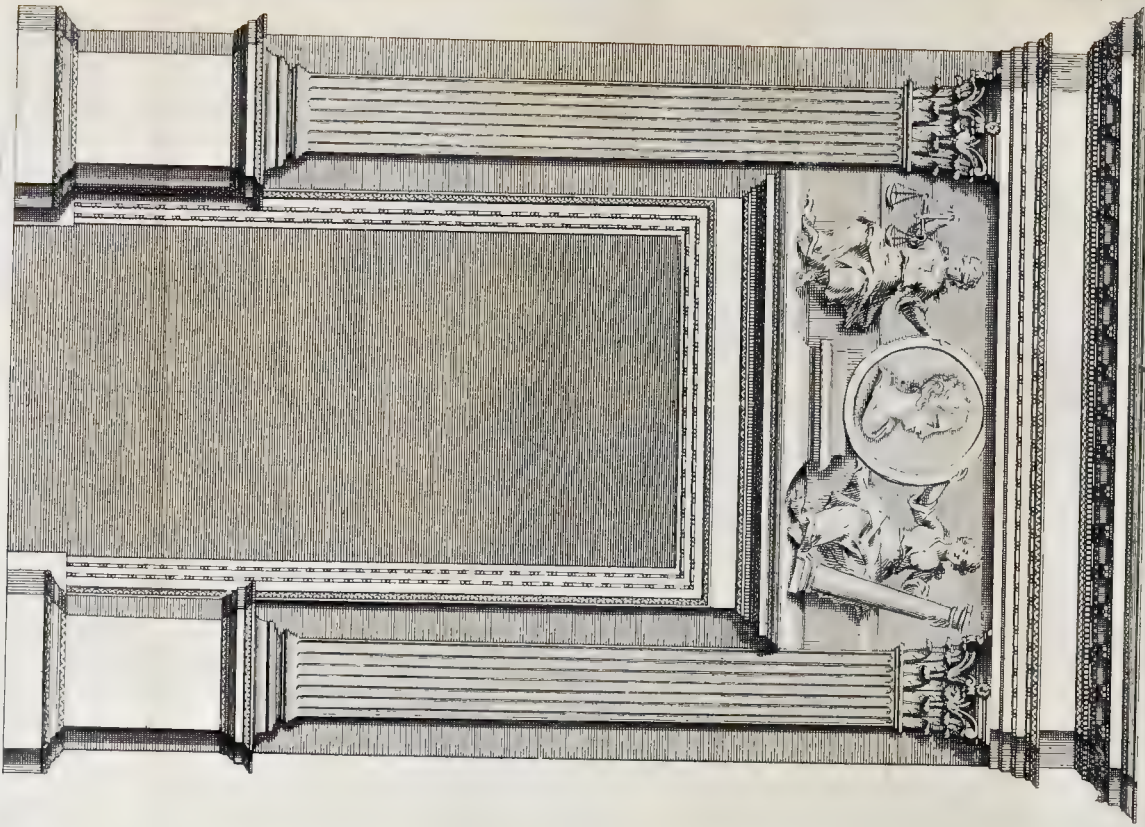


Jonick Sopheta



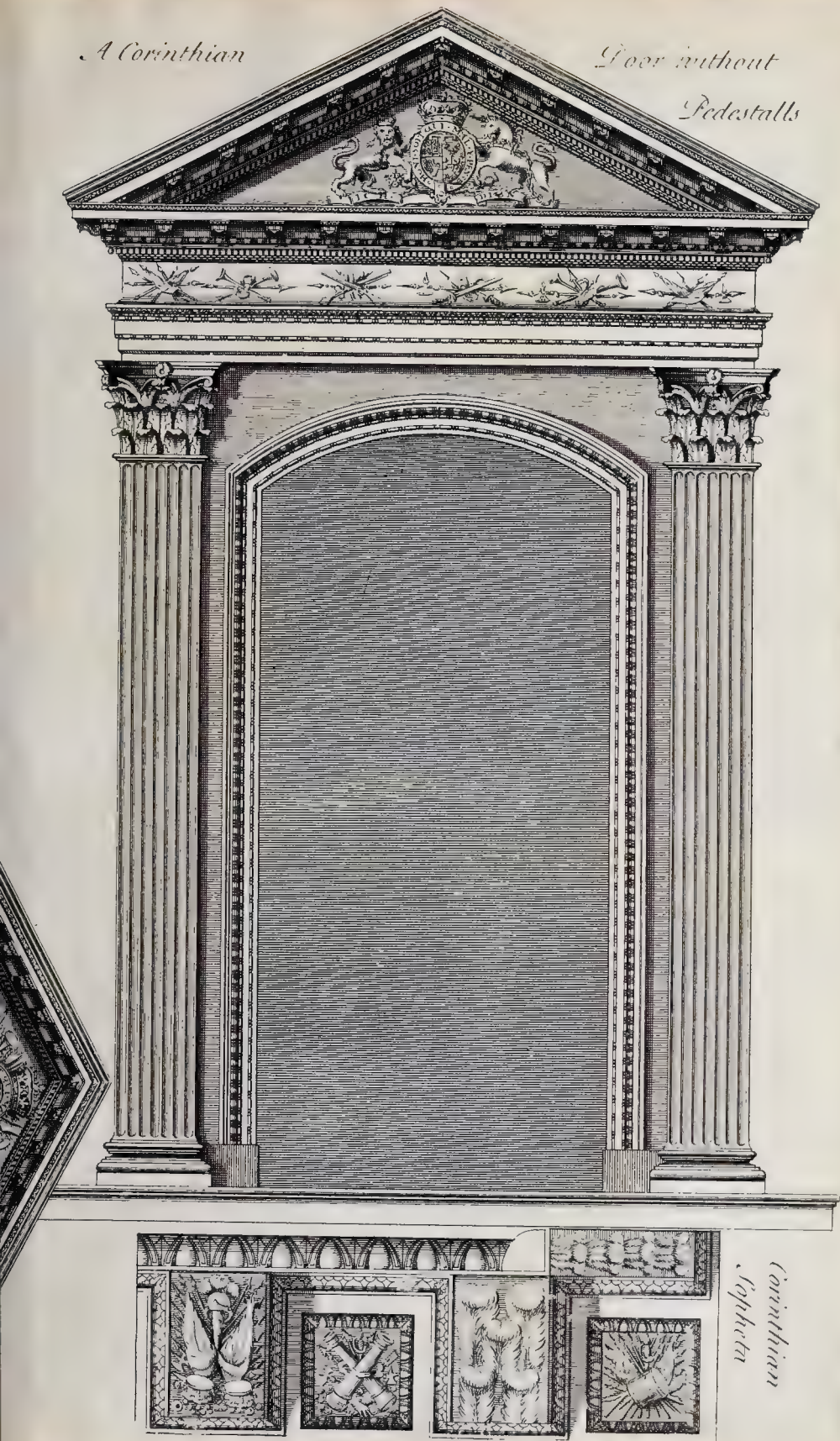






A Corinthian

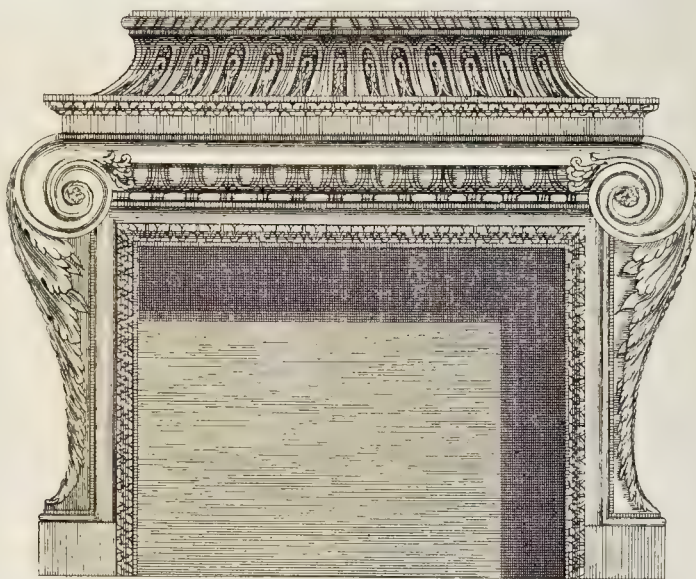
*Door without
Pedestals*



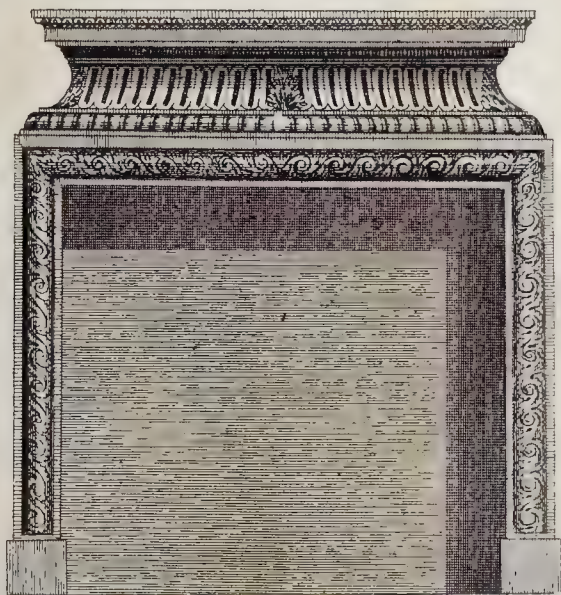
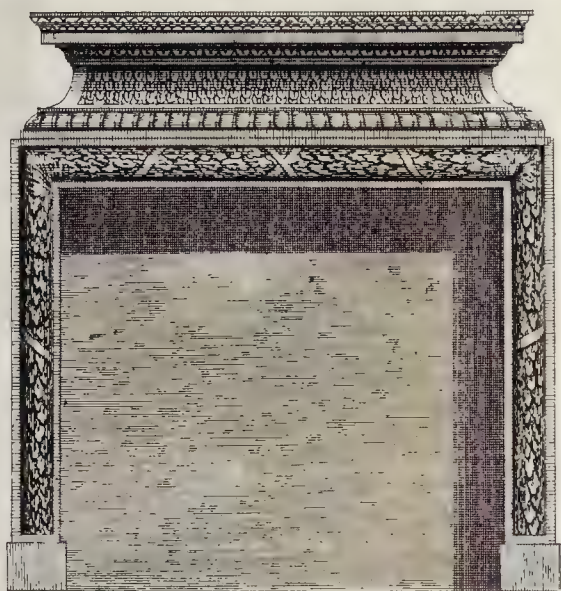
*Corinthian
Fopbeta*

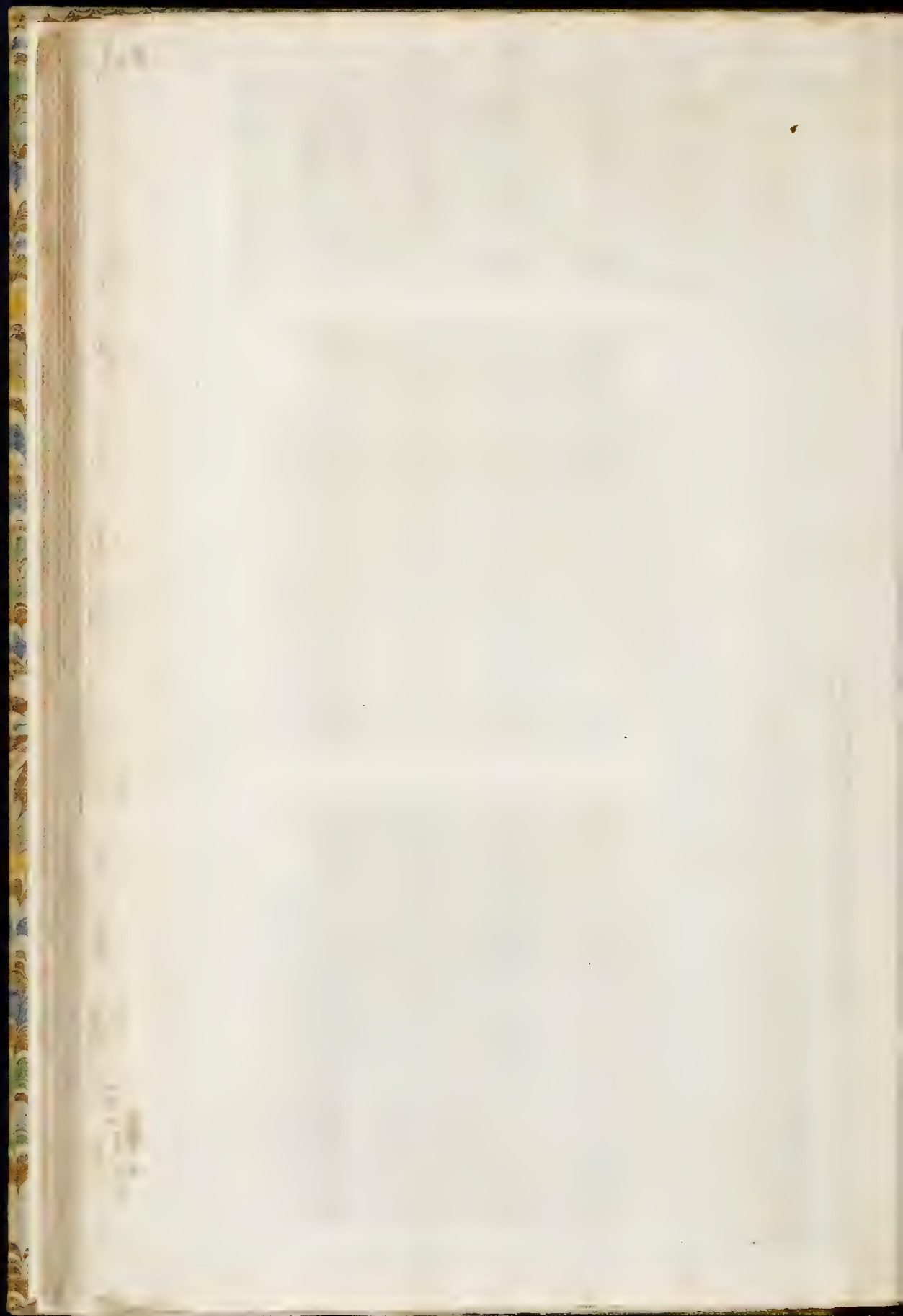




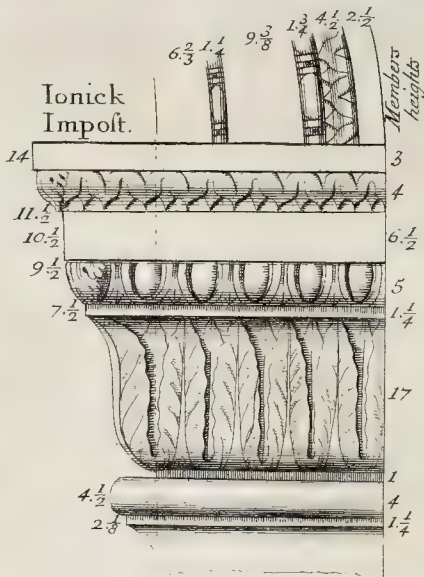
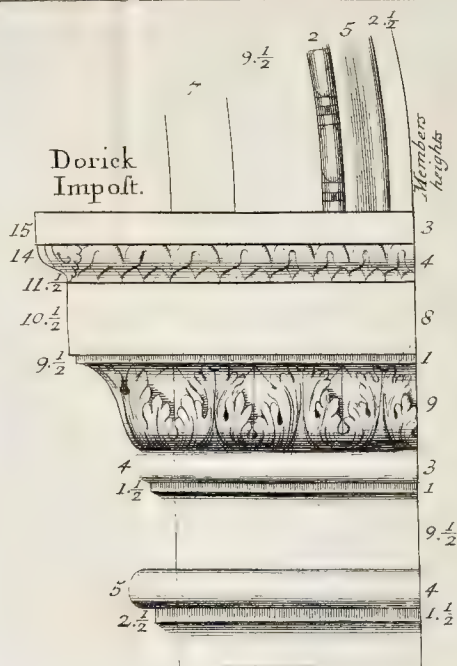


An Ornament for a Corinthian Frieze

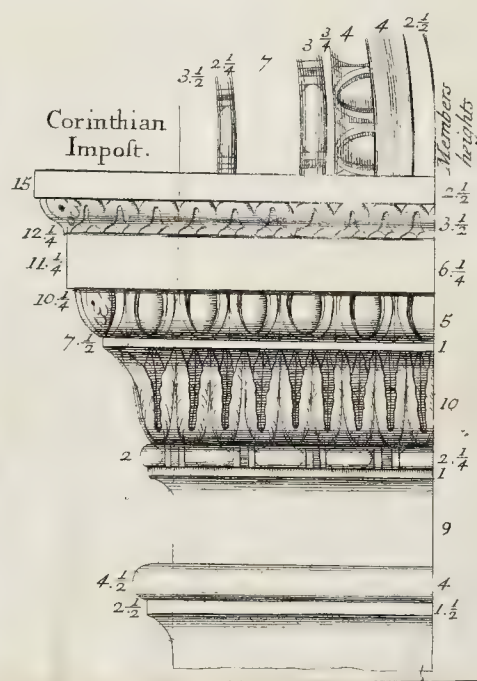
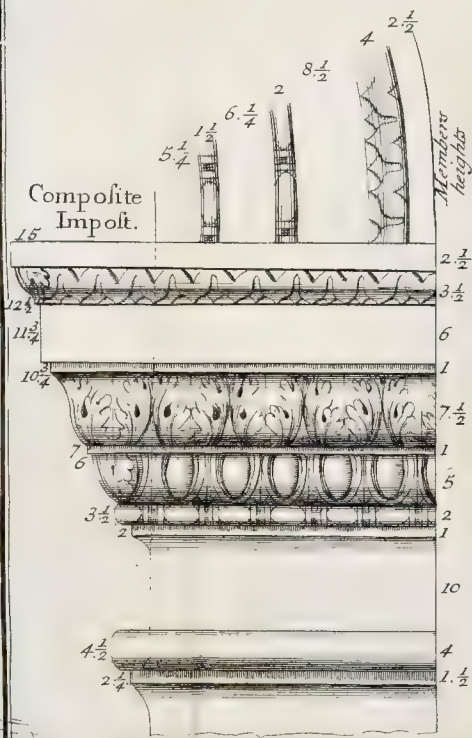
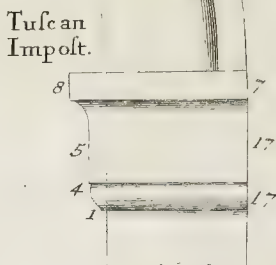


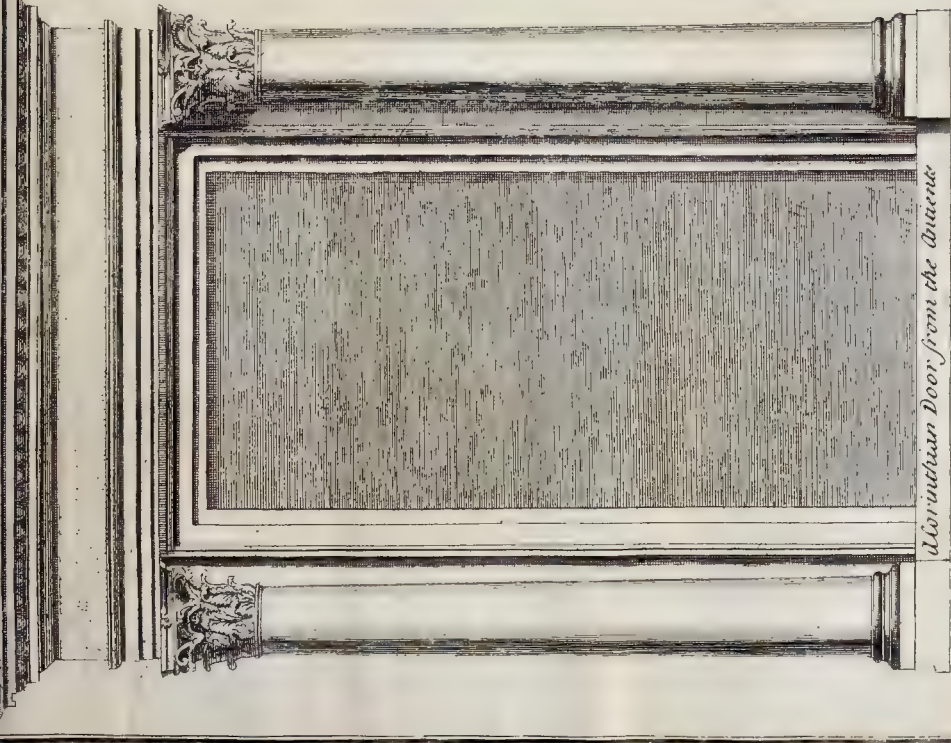




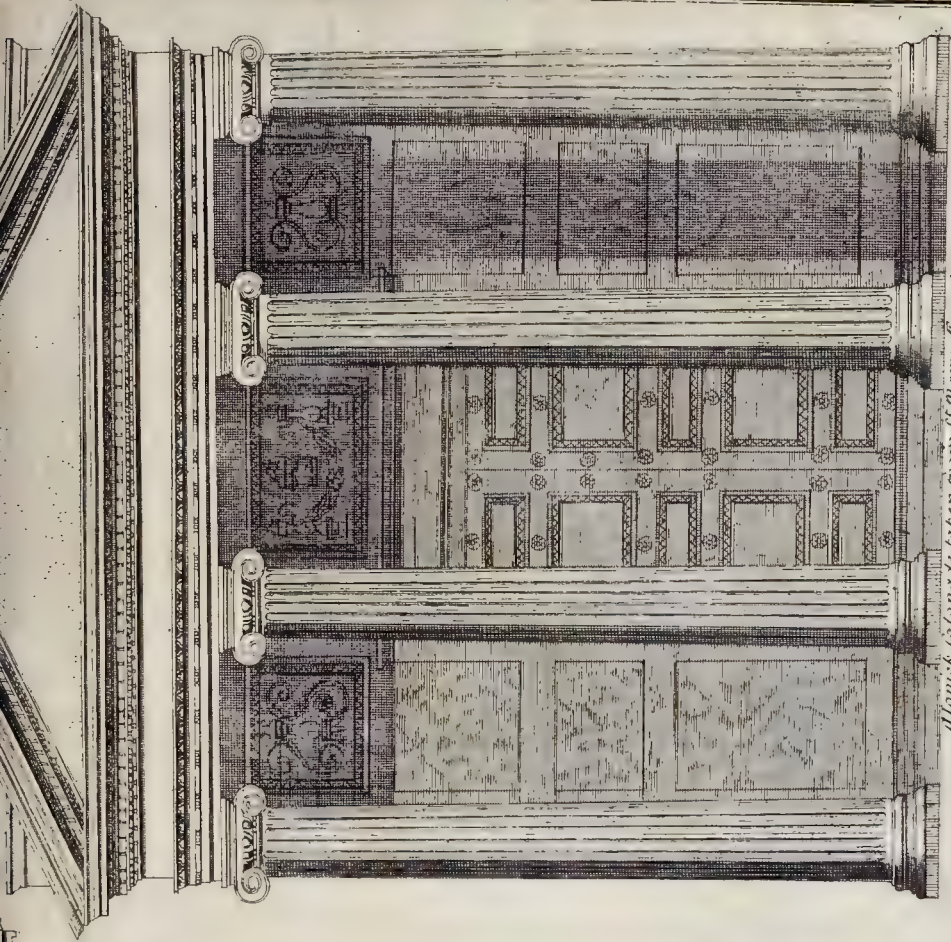


Imposts and Ornaments
of the
TUSCAN. DORICK. IONICK.
CORINTHIAN and COMPOSITE
Orders of Architecture.





Worvethan Door from the Quene



Monks' Window taken from St. Mary's Church

